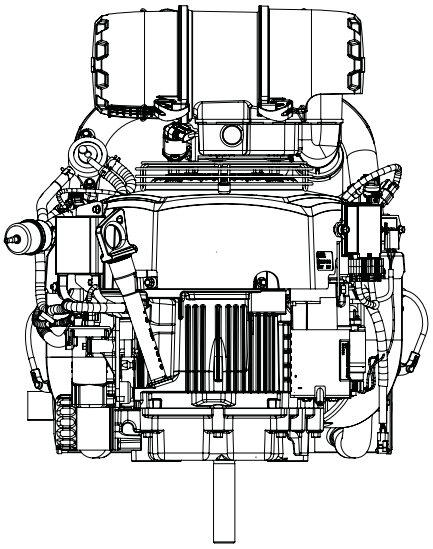
KOHLER® Command PRO

ECV850, ECV860, ECV870, ECV880

Service Manual



IMPORTANT: Read all safety precautions and instructions carefully before operating equipment. Refer to operating instruction of equipment that this engine powers.

Ensure engine is stopped and level before performing any maintenance or service.

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Safety

SAFETY PRECAUTIONS

⚠ **WARNING:** A hazard that could result in death, serious injury, or substantial property damage.

⚠ **CAUTION:** A hazard that could result in minor personal injury or property damage.

NOTE: is used to notify people of important installation, operation, or maintenance information.

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Do not fill fuel tank while engine is hot or running.

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.

⚠ WARNING

Rotating Parts can cause severe injury.

Stay away while engine is in operation.

Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate engine with covers, shrouds, or guards removed.

⚠ WARNING

Carbon Monoxide can cause severe nausea, fainting or death.

Avoid inhaling exhaust fumes.

Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled.

⚠ WARNING

Accidental Starts can cause severe injury or death.

Disconnect and ground spark plug lead(s) before servicing.

Before working on engine or equipment, disable engine as follows: 1) Disconnect spark plug lead(s). 2) Disconnect negative (–) battery cable from battery.

⚠ WARNING

Hot Parts can cause severe burns.

Do not touch engine while operating or just after stopping.

Never operate engine with heat shields or guards removed.

⚠ WARNING

Cleaning Solvents can cause severe injury or death.

Use only in well ventilated areas away from ignition sources.

Carburetor cleaners and solvents are extremely flammable. Follow cleaner manufacturer's warnings and instructions on its proper and safe use. Never use gasoline as a cleaning agent.

⚠ CAUTION

Electrical Shock can cause injury.

Do not touch wires while engine is running.

⚠ CAUTION

Damaging Crankshaft and Flywheel can cause personal injury.

Using improper procedures can lead to broken fragments. Broken fragments could be thrown from engine. Always observe and use precautions and procedures when installing flywheel.

⚠ CAUTION

Failure to utilize or reassemble debris screen as designed could result in debris screen failure and serious personal injury.

⚠ WARNING

High Pressure Fluids can puncture skin and cause severe injury or death.

Do not work on fuel system without proper training or safety equipment.

Fluid puncture injuries are highly toxic and hazardous. If an injury occurs, seek immediate medical attention.

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Fuel system ALWAYS remains under HIGH PRESSURE.

Wrap a shop towel completely around fuel pump module connector. Press release button(s) and slowly pull connector away from fuel pump module allowing shop towel to absorb any residual fuel in high pressure fuel line. Any spilled fuel must be completely wiped up immediately.

MAINTENANCE INSTRUCTIONS

	⚠ WARNING Accidental Starts can cause severe injury or death. Disconnect and ground spark plug lead(s) before servicing.	Before working on engine or equipment, disable engine as follows: 1) Disconnect spark plug lead(s). 2) Disconnect negative (–) battery cable from battery.

Normal maintenance, replacement or repair of emission control devices and systems may be performed by any repair establishment or individual; however, warranty repairs must be performed by a Kohler authorized dealer.

MAINTENANCE SCHEDULE

Every 100 Hours or Annually[1]

● Change oil. Oil filter is recommended.	Lubrication System
● Remove cooling shrouds and clean cooling areas.	Air Cleaner/Intake

Every 150 Hours[1]

● Check air cleaner element.	Air Cleaner/Intake
● Replace unique Electronic Fuel Injection (EFI) fuel filter.	
● Check oil cooler fins, clean as necessary (if equipped).	Lubrication System

Every 200 Hours

● Change oil filter.	Lubrication System

Every 300 Hours

● Replace air cleaner element and check inner element (if equipped).	Air Cleaner/Intake

Every 500 Hours or Annually[1]

● Replace spark plugs and set gap.	Electrical System

Every 600 Hours

● Replace air cleaner inner element (if equipped).	Air Cleaner/Intake

Every 600 Hours[2]

● Have valve lash checked/adjusted.

[1] Perform these procedures more frequently under severe, dusty, dirty conditions.
[2] Have a Kohler authorized dealer perform this service.

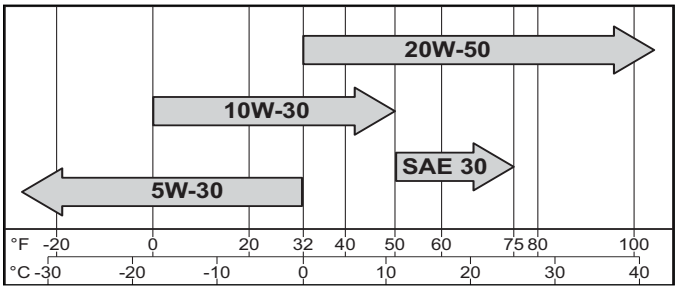
REPAIRS/SERVICE PARTS

Kohler genuine service parts can be purchased from Kohler authorized dealers. To find a local Kohler authorized dealer visit KohlerEngines.com or call 1-800-544-2444 (U.S. and Canada).

Maintenance

OIL RECOMMENDATIONS

We recommend use of Kohler oils for best performance. Other high-quality detergent oils (including synthetic) of API (American Petroleum Institute) service class SJ or higher are acceptable. Select viscosity based on air temperature at time of operation as shown in table below.



FUEL RECOMMENDATIONS

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Do not fill fuel tank while engine is hot or running.

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.

NOTE: E15, E20 and E85 are NOT approved and should NOT be used; effects of old, stale or contaminated fuel are not warrantable.

Fuel must meet these requirements:

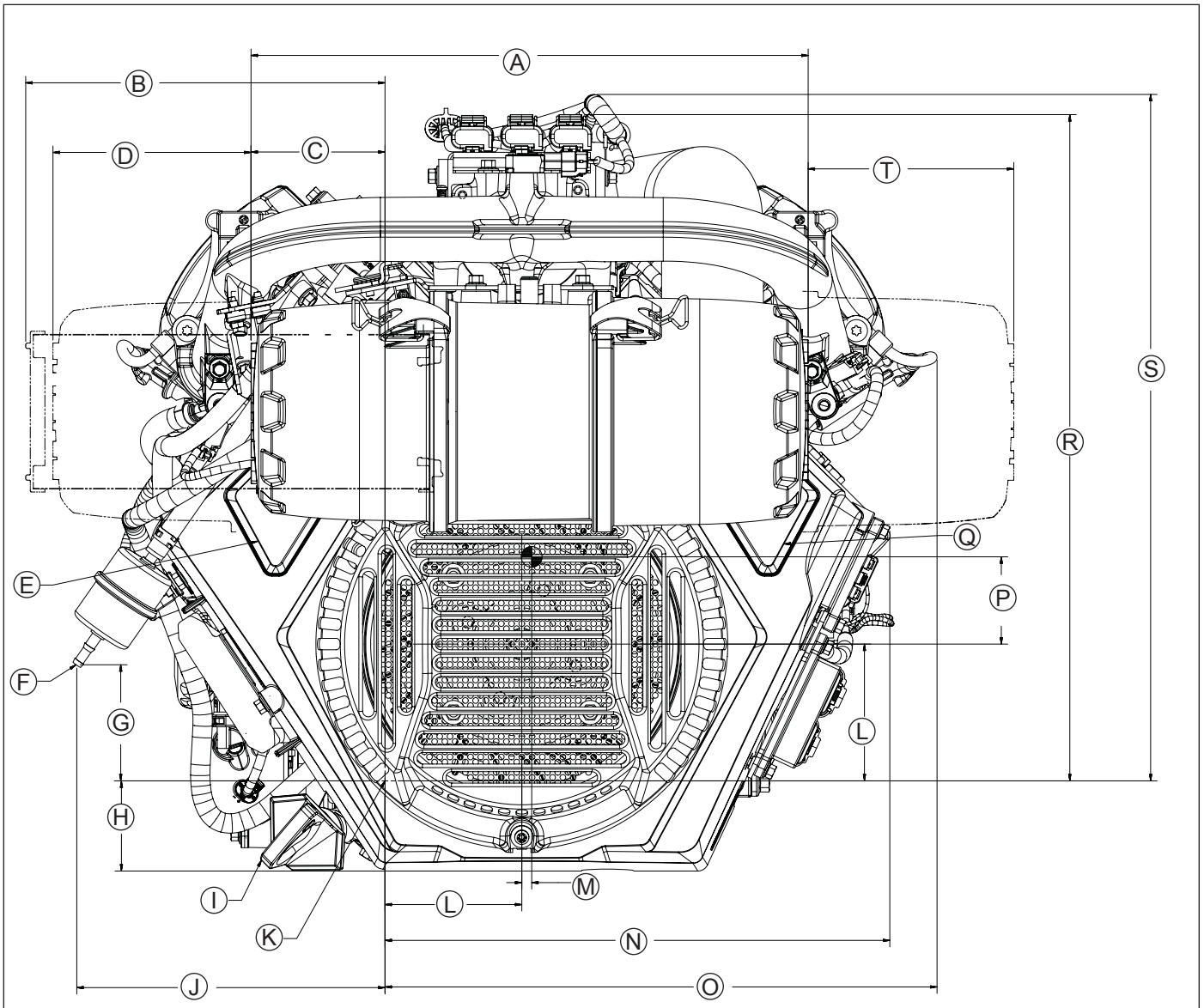
- Clean, fresh, unleaded gasoline.
- Octane rating of 87 (R+M)/2 or higher.
- Research Octane Number (RON) 90 octane minimum.
- Gasoline up to 10% ethyl alcohol, 90% unleaded is acceptable.
- Methyl Tertiary Butyl Ether (MTBE) and unleaded gasoline blend (max 15% MTBE by volume) are approved.
- Do not add oil to gasoline.
- Do not overfill fuel tank.
- Do not use gasoline older than 30 days.

STORAGE

If engine will be out of service for 2 months or more follow procedure below.

1. Add Kohler PRO Series fuel treatment or equivalent to fuel tank. Run engine 2-3 minutes to get stabilized fuel into fuel system (failures due to untreated fuel are not warrantable).
2. Change oil while engine is still warm from operation. Remove spark plug(s) and pour about 1 oz. of engine oil into cylinder(s). Replace spark plug(s) and crank engine slowly to distribute oil.
3. Disconnect negative (-) battery cable.
4. Store engine in a clean, dry place.

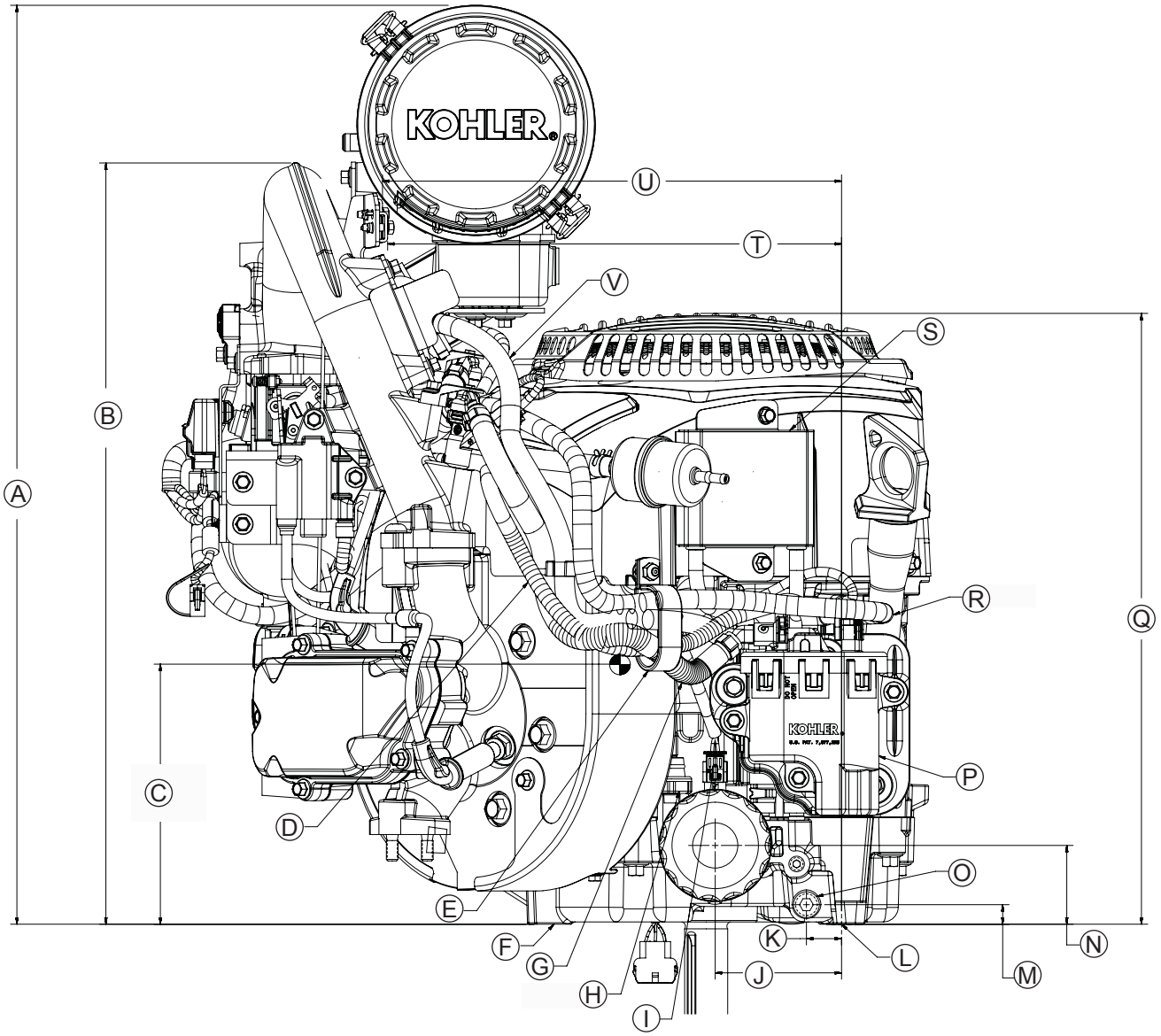
Engine Dimensions-Flywheel Side



A	365.7 mm (14.40 in.)	**B**	Air Filter Element Removal 235.8 mm (9.29 in.)	**C**	88.0 mm (3.46 in.)	**D**	Air Filter Cover Removal 130.0 mm (5.12 in.)
E	Cylinder #2 Clean-Out Cover	**F**	Fuel Line Connection Point	**G**	Flexible 76.2 mm (3.00 in.)	**H**	59.2 mm (2.33 in.)
I	Oil Fill and Dipstick (Yellow)	**J**	Flexible 202.3 mm (7.97 in.)	**K**	Mounting Hole "A" (In Oil Pan)	**L**	89.8 mm (3.54 in.)
M	Center of Gravity 6.5 mm (0.26 in.)	**N**	331.3 mm (13.05 in.)	**O**	Flexible 362.4 mm (14.27 in.)	**P**	Center of Gravity 57.3 mm (2.26 in.)
Q	Cylinder #1 Clean-Out Cover	**R**	Fuses 3 X 437.4 mm (17.22 in.)	**S**	Flexible 450.7 mm (17.74 in.)	**T**	Rain Cap Cover Removal 135.0 mm (5.31 in.)

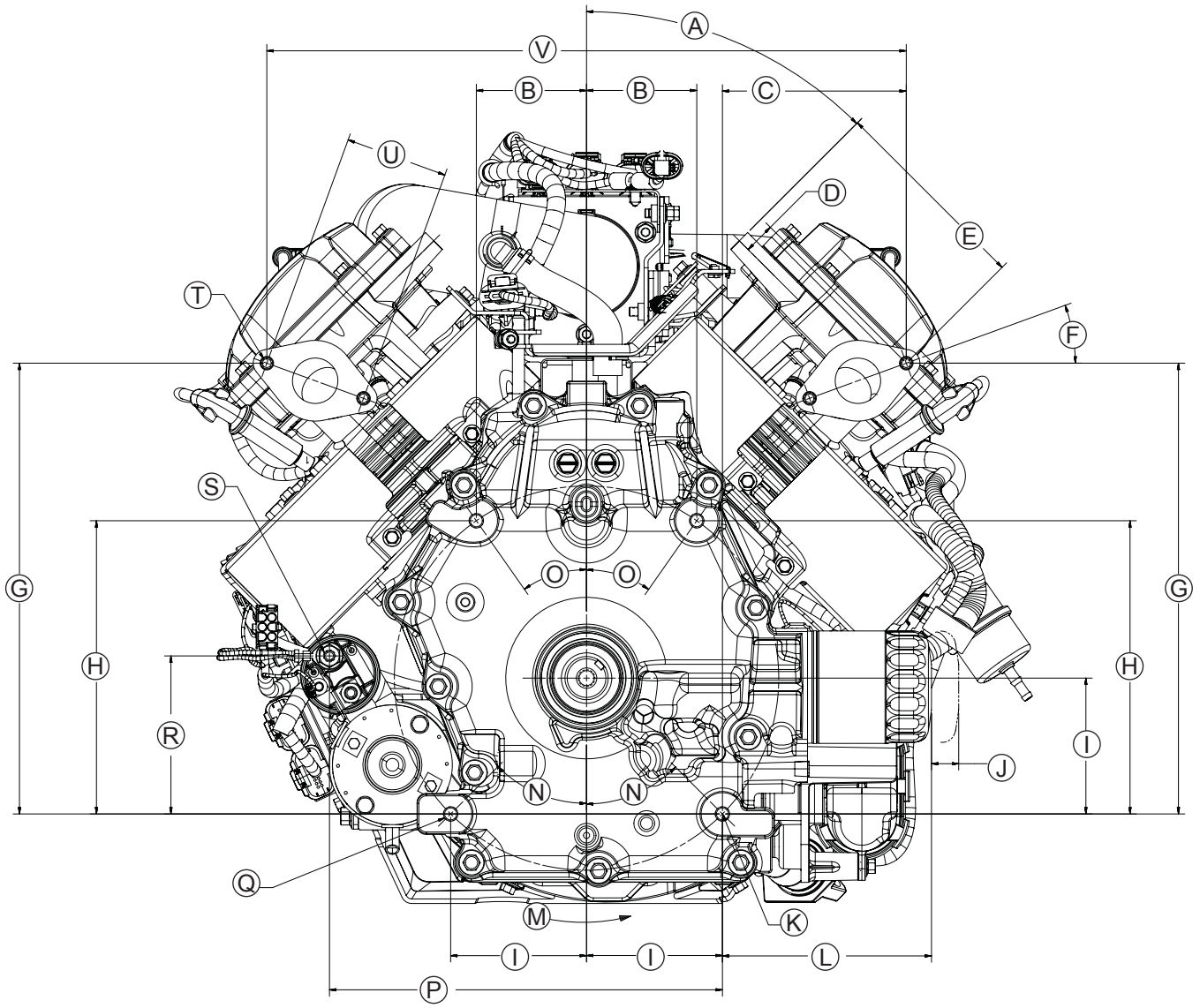
Specifications

Engine Dimensions-Oil Filter Side



A	Air Cleaner Top 609.5 mm (24.00 in.)	**B**	Intake Manifold Top 504.9 mm (19.88 in.)	**C**	Center of Gravity 172.5 mm (6.79 in.)	**D**	Evap Hose
E	Hose Retention Clamp	**F**	Engine Mounting Surface	**G**	High Pressure Fuel Outlet Hose	**H**	Oil Pressure Switch
I	Oil Temperature Switch	**J**	Oil Filter 83.8 mm (3.30 in.)	**K**	23.3 mm (0.92 in.)	**L**	Mounting Hole “A”
M	13.0 mm (0.51 in.)	**N**	Oil Filter 52.2 mm (2.06 in.)	**O**	Oil Drain Plug 3/8 in. NPTF	**P**	Fuel Pump Module
Q	Guard Top 405.1 mm (15.95 in.)	**R**	Pulse Hose	**S**	Oil Cooler (Optional)	**T**	Throttle Clamp Position #1 301.1 mm (11.85 in.)
U	Throttle Clamp Position #2 304.5 mm (11.99 in.)	**V**	Low Pressure Fuel Hose				

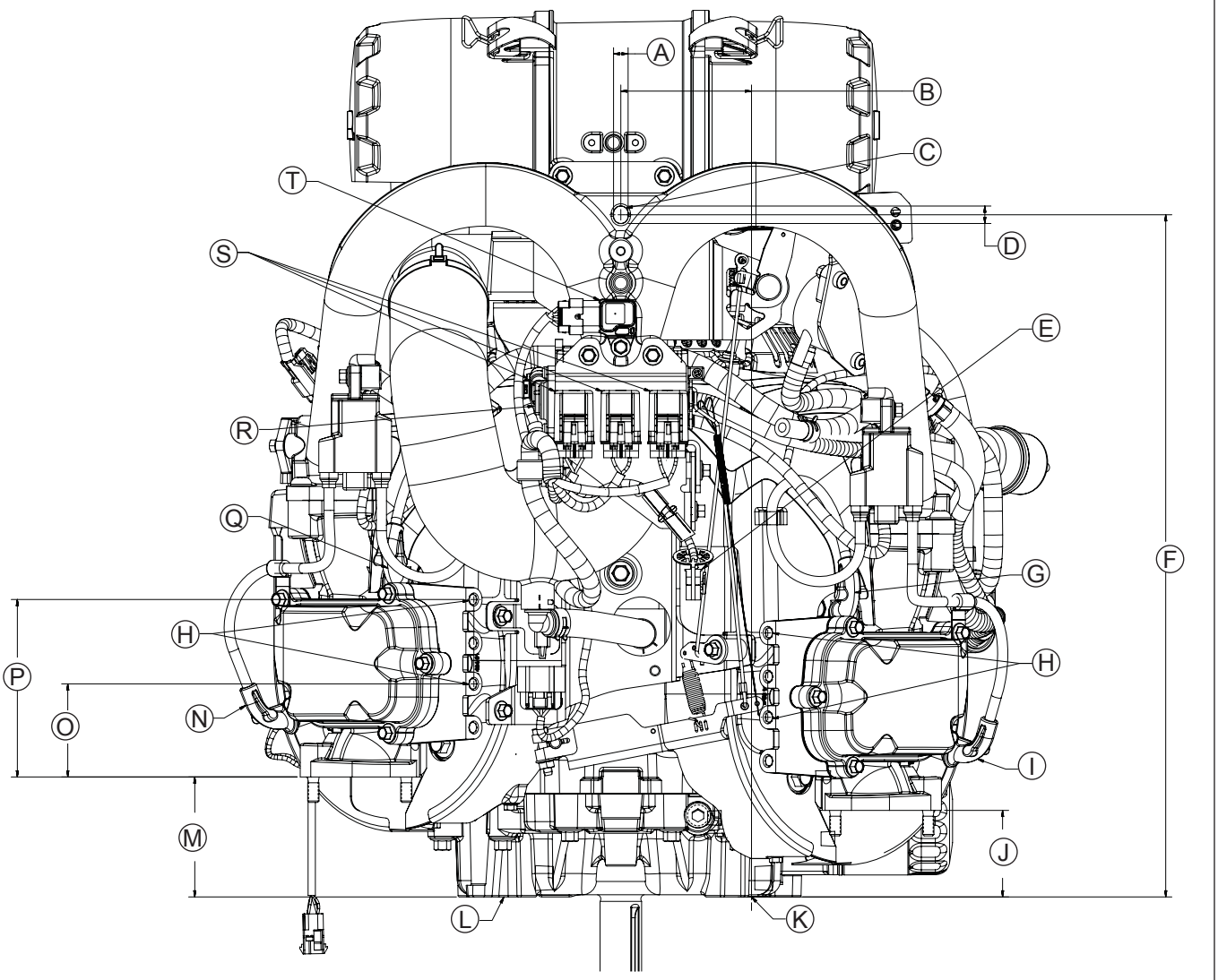
Engine Dimensions-Engine Mounting Surface (PTO End)



A	2 X 45°	**B**	72.8 mm (2.87 in.)	**C**	121.5 mm (4.78 in.)	**D**	2 X 20.8 mm (0.82 in.)
E	2 X 135.2 mm (5.32 in.)	**F**	2 X 20°	**G**	298.0 mm (11.73 in.)	**H**	193.8 mm (7.63 in.)
I	89.8 mm (3.54 in.)	**J**	Oil Filter Removal 18.0 mm (0.71 in.)	**K**	Mounting Hole "A"	**L**	138.1 mm (5.44 in.)
M	Direction of Rotation	**N**	45°	**O**	35°	**P**	Starter Stud 259.7 mm (10.22 in.)
Q	4 X 3/8-16 UNC-2B in. 25 mm (0.98 in.) Deep on a Ø 254 mm (10.0 in.) B.C.	**R**	Starter Stud 104.5 mm (4.11 in.)	**S**	M8 X 1.25 mm Stud/Nut	**T**	4 X M8 X 1.25 mm Studs
U	2 X 68.0 mm (2.68 in.)	**V**	422.6 mm (16.64 in.)				

Specifications

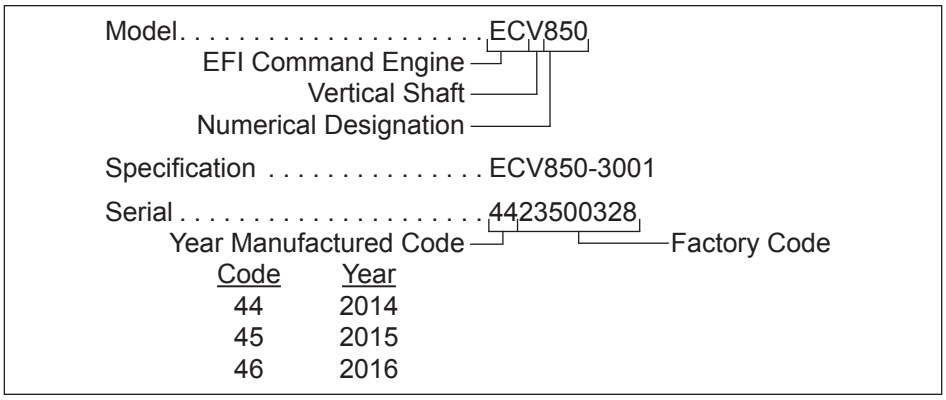
Engine Dimensions-Valve Cover Side



A	10.0 mm (0.39 in.)	**B**	89.8 mm (3.54 in.)	**C**	Lift Hook Location #1	**D**	12.0 mm (0.47 in.)
E	Diagnostic Connector	**F**	469.0 mm (18.46 in.)	**G**	Cylinder #2 Upper Spark Plug Lead Wire Boot	**H**	M8 X 1.25 mm Muffler Bracket Support Mounting Locations (Optional)
I	Cylinder #2 Lower Spark Plug Lead Wire Boot	**J**	Exhaust Port #2 59.5 mm (2.34 in.)	**K**	Mounting Hole "A"	**L**	Engine Mounting Surface
M	Exhaust Port #1 82.5 mm (3.25 in.)	**N**	Cylinder #1 Lower Spark Plug Lead Wire Boot	**O**	2 X 64.0 mm (2.52 in.)	**P**	2 X 122.0 mm (4.80 in.)
Q	Cylinder #1 Upper Spark Plug Lead Wire Boot	**R**	Throttle Position Sensor	**S**	Fuses	**T**	Temperature/ Manifold Air Pressure (TMAP) Sensor

ENGINE IDENTIFICATION NUMBERS

Kohler engine identification numbers (model, specification and serial) should be referenced for efficient repair, ordering correct parts, and engine replacement.



GENERAL SPECIFICATIONS[3,6]	ECV850 ECV860 ECV870 ECV880
Bore	86 mm (3.39 in.)
Stroke	70.9 mm (2.79 in.)
Displacement	824 cc (50.3 cu. in.)
Oil Capacity (refill)	2.6 L (2.7 U.S. qt.)
Maximum Angle of Operation (@ full oil level)[4]	25°

TORQUE SPECIFICATIONS[3,5]	ECV850 ECV860 ECV870 ECV880
Blower Housing	
M6 Screw	4.8 N·m (42 in. lb.)
M6 Nut	4.8 N·m (42 in. lb.)
Clean-out cover Screw	3.1 N·m (27 in. lb.)
Baffles and Brackets	
Crankcase Baffle M6 Screw	11.3 N·m (100 in. lb.) into a new hole 7.7 N·m (68 in. lb.) into a used hole
Crankcase Baffle M6 Nut	8.2 N·m (73 in. lb.)
Cylinder Barrel Baffle M6 Screw	8.2 N·m (73 in. lb.)
Cylinder Barrel Baffle M5 Screw	6.3 N·m (56 in. lb.) into a new hole 4.0 N·m (35 in. lb.) into a used hole
Throttle Body Bracket M8 Screw	16.0 N·m (142 in. lb.)
Throttle Body Bracket M6 Screw	10.2 N·m (90 in. lb.)
Valley Baffle Assembly M6 Screw	8.2 N·m (73 in. lb.)

[3] Values are in Metric units. Values in parentheses are English equivalents.

[4] Exceeding maximum angle of operation may cause engine damage from insufficient lubrication.

[5] Lubricate threads with engine oil prior to assembly.

[6] Any and all horsepower (hp) references by Kohler are Certified Power Ratings and per SAE J1940 & J1995 hp standards. Details on Certified Power Ratings can be found at KohlerEngines.com.

Specifications

TORQUE SPECIFICATIONS[3,5]	ECV850 ECV860 ECV870 ECV880
Intake Manifold, Air Cleaner, Throttle Body	
Intake Manifold Mounting Fastener	16.0 N·m (142 in. lb.)
Throttle Body to Intake Manifold Mounting Nut	6.8 N·m (60 in. lb.)
Throttle Body Mounting Stud (into intake manifold)	6.0 N·m (53 in. lb.)
Throttle Lever Adapter to Throttle Body Nut	6.8 N·m (60 in. lb.)
Air Cleaner Support Bracket to Throttle Body Bracket Fastener	10.2 N·m (90 in. lb.)
Air Cleaner Support Bracket to Air Cleaner Housing Fastener	5.8 N·m (51 in. lb.)
Fuel Injector Cap Fastener	7.3 N·m (65 in. lb.)
Fuse Holder Bracket to Manifold Screw	10.2 N·m (90 in. lb.)
Temperature/Manifold Air Pressure (TMAP) Sensor Fastener	7.3 N·m (65 in. lb.)
Connecting Rod	
Cap Fastener (torque in increments)	11.6 N·m (103 in. lb.)
Crankcase	
Breather Cover Fastener	11.3 N·m (100 in. lb.)
Breather Reed Retainer Fastener	11.3 N·m (100 in. lb.)
Oil Fill Tube Screw	7.7 N·m (68 in. lb.)
Cylinder Head	
Fastener (torque in 2 increments) Head Bolt	first to 23.7 N·m (210 in. lb.) finally to 46.9 N·m (415 in. lb.)
Rocker Arm Stud	24.0 N·m (212 in. lb.)
Rocker Pivot Set Screw	7.8 N·m (69 in. lb.)
Debris Screen	
Fastener	9.9 N·m (88 in. lb.)
Flywheel	
Retaining Screw	71.6 N·m (53 ft. lb.)
Fixed Guard	
Fastener	1.4 N·m (12 in. lb.)
Fuel Pump Module/Fuel Pump	
Module Baffle to Crankcase Fastener	11.9 N·m (105 in. lb.) into new hole 7.8 N·m (69 in. lb.) into used hole
Module to Baffle Fastener	9.2 N·m (81 in. lb.)
Pulse Pump Bracket Screw (to intake manifold)	8.2 N·m (73 in. lb.)
Pulse Pump Screw (to bracket)	8.2 N·m (73 in. lb.)
Fuse Cover (Optional)	
Bracket Stud	9.9 N·m (88 in. lb.)
Retaining Nut	9.9 N·m (88 in. lb.)
Retaining Screw	9.9 N·m (88 in. lb.)

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[5] Lubricate threads with engine oil prior to assembly.

TORQUE SPECIFICATIONS[3,5]	ECV850 ECV860 ECV870 ECV880
Governor (Electronic)	
Governor Control Unit (GCU) to GCU Bracket Screw	3.1 N·m (27 in. lb.)
GCU/Control Bracket to Manifold Screw	10.2 N·m (90 in. lb.)
Digital Linear Actuator (DLA) Bracket to GCU Bracket Nut	10.2 N·m (90 in. lb.)
DLA to DLA Bracket Screw	4.1 N·m (35 in. lb.)
Governor (Mechanical)	
Lever Nut	7.1 N·m (63 in. lb.)
Ignition	
Spark Plug	27 N·m (20 ft. lb.)
Coil Fastener	10.2 N·m (90 in. lb.)
Crankshaft Position Sensor Fastener	8.2 N·m (73 in. lb.) into a new hole 7.7 N·m (68 in. lb.) into a used hole
Electronic Control Unit (ECU) Fastener	5.6 N·m (50 in. lb.)
Rectifier-Regulator Fastener	5.6 N·m (50 in. lb.)
Muffler	
Retaining Nut	27.8 N·m (246 in. lb.)
Bracket Fastener	16.0 N·m (142 in. lb.)
Oil Cooler (Optional)	
Fastener Top (M5) Bottom (M6)	 5.6 N·m (50 in. lb.) 4.8 N·m (50 in. lb.)
Oil Pan	
Fastener	25.6 N·m (227 in. lb.)
Oil Drain Plug	21.4 N·m (15.7 ft. lb.)
Oil Temperature Sensor	7.3 N·m (65 in. lb.)
Oil Sentry™ Pressure Switch	9.0 N·m (80 in. lb.)
Oil Pump Cover Fastener	11.3 N·m (100 in. lb.) into new holes 7.8 N·m (69 in. lb.) into used holes
Solenoid (starter)	
Mounting Hardware	4.0-6.0 N·m (35-53 in. lb.)
Nut, Positive (+) Brush Lead	8.0-11.0 N·m (71-97 in. lb.)
Starter Assembly	
Thru Bolt	5.6-9.0 N·m (49-79 in. lb.)
Mounting Screw	16.0 N·m (142 in. lb.)
Brush Holder Mounting Screw	2.5-3.3 N·m (22-29 in. lb.)
Stator	
Mounting Screw	9.3 N·m (82 in. lb.) into new holes 4.0 N·m (35 in. lb.) into used holes
Valve Cover	
Fastener	10.9 N·m (96 in. lb.)

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[5] Lubricate threads with engine oil prior to assembly.

Specifications

CLEARANCE SPECIFICATIONS[3]	ECV850 ECV860 ECV870 ECV880
Camshaft	
End Play	0.147/0.495 mm (0.006/0.019 in.)
Running Clearance	0.025/0.105 mm (0.0010/0.0025 in.)
Bore I.D. New Max. Wear Limit	 20.000/20.025 mm (0.7874/0.7884 in.) 20.038 mm (0.7889 in.)
Bearing Surface O.D. New Max. Wear Limit	 19.920/19.975 mm (0.7842/0.7864 in.) 19.917 mm (0.7841 in.)
Cam Lobe Profile (minimum dimension, measured from base circle to top of lobe) Exhaust	 21.47 mm (0.8452 in.)
Intake	21.47 mm (0.8452 in.)
Connecting Rod	
Crankpin End I.D. @ 70°F New Max. Wear Limit	 48.030/48.037 mm (1.8910/1.8912 in.) 48.021 mm (1.8906 in.)
Connecting Rod-to-Crankpin Running Clearance New Max. Wear Limit	 0.030/0.055 mm (0.0012/0.0022 in.) 0.070 mm (0.0028 in.)
Connecting Rod-to-Crankpin Side Clearance	0.31/0.65 mm (0.0122/0.0256 in.)
Connecting Rod-to-Piston Pin Running Clearance	0.006/0.016 mm (0.0002/0.0006 in.)
Piston Pin End I.D. @ 70°F New Max. Wear Limit	 22.015/22.023 mm (0.8667/0.8670 in.) 22.036 mm (0.8676 in.)
Crankcase	
Governor Cross Shaft Bore I.D. (Mechanical Governor) New Max. Wear Limit	 7.949/8.000 mm (0.3130/0.3150 in.) 7.936 mm (0.3124 in.)
Crankshaft	
End Play (free)	0.104/0.532 mm (0.0041/0.0209 in.)
Bore (in crankcase) New	 45.043/45.069 mm (1.7733/1.7744 in.)
Crankshaft Bore (in crankcase)-to-Crankshaft Running Clearance New	 0.043/0.091 mm (0.0017/0.0036 in.)
Bore (in oil pan) New	 45.043/45.069 mm (1.7733/1.7744 in.)
Crankshaft Bore (in oil pan)-to-Crankshaft Running Clearance New	 0.043/0.091 mm (0.0017/0.0036 in.)
Oil Pan End Main Bearing Journal O.D. - New O.D. - Max. Wear Limit Max. Taper Max. Out-of-Round	 44.978/45.000 mm (1.7708/1.7716 in.) 44.908 mm (1.7680 in.) 0.022 mm (0.0009 in.) 0.025 mm (0.0010 in.)
Connecting Rod Journal O.D. - New O.D. - Max. Wear Limit Max. Taper Max. Out-of-Round Width	 53.00/53.15 mm (2.0866/2.0925 in.) 52.991 mm (2.0862 in.) 0.018 mm (0.0007 in.) 0.025 mm (0.0010 in.) 53.000/53.150 mm (2.0866/2.0925 in.)

[3] Values are in Metric units. Values in parentheses are English equivalents.

CLEARANCE SPECIFICATIONS[3]	ECV850	ECV860	ECV870	ECV880
Crankshaft Continued				
T.I.R. PTO End, Crank in Engine Entire Crank, in V-Blocks	0.279 mm (0.0110 in.) 0.025 mm (0.0001 in.)			
Flywheel End Main Bearing Journal O.D. - New O.D. - Max. Wear Limit Max. Taper Max. Out-of-Round	44.978/45.00 mm (1.770/1.771 in.) 44.908 mm (1.7680 in.) 0.022 mm (0.0009 in.) 0.025 mm (0.0010 in.)			
Cylinder Bore				
I.D. New Max. Wear Limit Max. Taper Max. Out-of-Round	86.000/86.025 mm (3.3858/3.3868 in.) 86.075 mm (3.3888 in.) 0.018 mm (0.0007 in.) 0.05 mm (0.0020 in.)			
Cylinder Head				
Max. Out-of-Flatness	0.08 mm (0.0031 in.)			
Governor (Mechanical)				
Cross Shaft O.D. New Max. Wear Limit	7.949/8.000 mm (0.3130/.3150 in.) 7.936 mm (0.3124 in.)			
Governor Gear Shaft-to-Governor Gear Running Clearance	0.16/0.90 mm (0.0063/0.0354 in.)			
Gear Shaft O.D. New Max. Wear Limit	5.990/6.000 mm (0.2358/0.2362 in.) 5.977 mm (0.2353 in.)			
Ignition				
Spark Plug Gap	0.76 mm (0.030 in.)			
Piston, Piston Rings, and Piston Pin				
Piston-to-Piston Pin Running Clearance	0.006/0.016 mm (0.0002/0.0006 in.)			
Pin Bore I.D. New Max. Wear Limit	22.06/22.12 mm (0.8685/0.8709 in.) 22.24 mm (0.8759 in.)			
Pin O.D. New Max. Wear Limit	21.996/22.000 mm (0.8660/0.8661 in.) 21.995 mm (0.8659 in.)			
Top Compression Ring-to-Groove Side Clearance	0.04/0.08 mm (0.0016/0.0031 in.)			
Middle Compression Ring-to-Groove Side Clearance	0.03/0.07 mm (0.0012/0.0028 in.)			
Oil Control Ring-to-Groove Side Clearance	0.06/0.19 mm (0.0024/0.0074 in.)			
Top Compression Ring End Gap New Bore Used Bore (max.)	0.15/0.30 mm (0.0059/0.0118 in.) 0.51 mm (0.0201 in.)			
Middle Compression Ring End Gap New Bore Used Bore (max.)	0.65/0.80 mm (0.0256/0.0315 in.) 1.33 mm (0.0524 in.)			

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Specifications

CLEARANCE SPECIFICATIONS[3]	ECV850	ECV860	ECV870	ECV880

Piston, Piston Rings, and Piston Pin Continued

Thrust Face O.D.[7] New Max. Wear Limit	 85.956/85.974 mm (3.3841/3.3848 in.) 85.82 mm (3.3787 in.)
Piston Thrust Face-to-Cylinder Bore[7] Running Clearance New	 0.026/0.069 mm (0.0010/0.0027 in.)

Valves and Valve Lifters

Intake and Exhaust Valve Lash	0.050/0.127 mm (0.0020/0.0050 in.)
Tappet to Crankcase Running Clearance	0.013/0.073 mm (0.0005/0.0029 in.)
Intake Valve Stem-to-Valve Guide Running Clearance	0.038/0.076 mm (0.0015/0.0030 in.)
Exhaust Valve Stem-to-Valv e Guide Running Clearance	0.050/0.088 mm (0.0020/0.0035 in.)
Intake Valve Guide I.D. New Max. Wear Limit	 7.038/7.058 mm (0.2771/0.2779 in.) 7.132 mm (0.2808 in.)
Exhaust Valve Guide I.D. New Max. Wear Limit	 7.038/7.058 mm (0.2771/0.2779 in.) 7.157 mm (0.2818 in.)
Guide Reamer Size Standard 0.25 mm O.S.	 7.048 mm (0.2775 in.) 7.298 mm (0.2873 in.)
Intake Valve Minimum Lift	9.35 mm (0.3681 in.)
Exhaust Valve Minimum Lift	9.35 mm (0.3681 in.)
Nominal Valve Face Angle	45°

[3] Values are in Metric units. Values in parentheses are English equivalents.

[7] Measure 11 mm (0.4331 in.) above bottom of piston skirt at right angles to piston pin.

GENERAL TORQUE VALUES

English Fastener Torque Recommendations for Standard Applications				
	Bolts, Screws, Nuts and Fasteners Assembled Into Cast Iron or Steel			Grade 2 or 5 Fasteners Into Aluminum
Size	Grade 2	Grade 5	Grade 8	
Tightening Torque: N·m (in. lb.) ± 20%				
8-32	2.3 (20)	2.8 (25)	—	2.3 (20)
10-24	3.6 (32)	4.5 (40)	—	3.6 (32)
10-32	3.6 (32)	4.5 (40)	—	—
1/4-20	7.9 (70)	13.0 (115)	18.7 (165)	7.9 (70)
1/4-28	9.6 (85)	15.8 (140)	22.6 (200)	—
5/16-18	17.0 (150)	28.3 (250)	39.6 (350)	17.0 (150)
5/16-24	18.7 (165)	30.5 (270)	—	—
3/8-16	29.4 (260)	—	—	—
3/8-24	33.9 (300)	—	—	—
Tightening Torque: N·m (ft. lb.) ± 20%				
5/16-24	—	—	40.7 (30)	—
3/8-16	—	47.5 (35)	67.8 (50)	—
3/8-24	—	54.2 (40)	81.4 (60)	—
7/16-14	47.5 (35)	74.6 (55)	108.5 (80)	—
7/16-20	61.0 (45)	101.7 (75)	142.5 (105)	—
1/2-13	67.8 (50)	108.5 (80)	155.9 (115)	—
1/2-20	94.9 (70)	142.4 (105)	223.7 (165)	—
9/16-12	101.7 (75)	169.5 (125)	237.3 (175)	—
9/16-18	135.6 (100)	223.7 (165)	311.9 (230)	—
5/8-11	149.5 (110)	244.1 (180)	352.6 (260)	—
5/8-18	189.8 (140)	311.9 (230)	447.5 (330)	—
3/4-10	199.3 (147)	332.2 (245)	474.6 (350)	—
3/4-16	271.2 (200)	440.7 (325)	637.3 (470)	—

Metric Fastener Torque Recommendations for Standard Applications						
	Property Class					Noncritical Fasteners Into Aluminum
Size	4.8	5.8	8.8	10.9	12.9	
Tightening Torque: N·m (in. lb.) ± 10%						
M4	1.2 (11)	1.7 (15)	2.9 (26)	4.1 (36)	5.0 (44)	2.0 (18)
M5	2.5 (22)	3.2 (28)	5.8 (51)	8.1 (72)	9.7 (86)	4.0 (35)
M6	4.3 (38)	5.7 (50)	9.9 (88)	14.0 (124)	16.5 (146)	6.8 (60)
M8	10.5 (93)	13.6 (120)	24.4 (216)	33.9 (300)	40.7 (360)	17.0 (150)
Tightening Torque: N·m (ft. lb.) ± 10%						
M10	21.7 (16)	27.1 (20)	47.5 (35)	66.4 (49)	81.4 (60)	33.9 (25)
M12	36.6 (27)	47.5 (35)	82.7 (61)	116.6 (86)	139.7 (103)	61.0 (45)
M14	58.3 (43)	76.4 (56)	131.5 (97)	184.4 (136)	219.7 (162)	94.9 (70)

Torque Conversions	
N·m = in. lb. x 0.113	in. lb. = N·m x 8.85
N·m = ft. lb. x 1.356	ft. lb. = N·m x 0.737

Tools and Aids

Certain quality tools are designed to help you perform specific disassembly, repair, and reassembly procedures. By using these tools, you can properly service engines easier, faster, and safer! In addition, you'll increase your service capabilities and customer satisfaction by decreasing engine downtime.

Here is a list of tools and their source.

SEPARATE TOOL SUPPLIERS

Kohler Tools
Contact your local Kohler source of supply.

SE Tools
415 Howard St.
Lapeer, MI 48446
Phone 810-664-2981
Toll Free 800-664-2981
Fax 810-664-8181

Design Technology Inc.
768 Burr Oak Drive
Westmont, IL 60559
Phone 630-920-1300
Fax 630-920-0011

TOOLS

Description	Source/Part No.
Alcohol Content Tester For testing alcohol content (%) in reformulated/oxygenated fuels.	Kohler 25 455 11-S
Camshaft Endplay Plate For checking camshaft endplay.	SE Tools KLR-82405
Camshaft Seal Protector (Aegis) For protecting seal during camshaft installation.	SE Tools KLR-82417
Cylinder Leakdown Tester For checking combustion retention and if cylinder, piston, rings, or valves are worn. Individual component available: Adapter 12 mm x 14 mm (Required for leakdown test on XT-6 engines)	Kohler 25 761 05-S Design Technology Inc. DTI-731-03
Dealer Tool Kit (Domestic) Complete kit of Kohler required tools. Components of 25 761 39-S Ignition System Tester Cylinder Leakdown Tester Oil Pressure Test Kit Rectifier-Regulator Tester (120 V AC/60Hz)	Kohler 25 761 39-S Kohler 25 455 01-S Kohler 25 761 05-S Kohler 25 761 06-S Kohler 25 761 20-S
Dealer Tool Kit (International) Complete kit of Kohler required tools. Components of 25 761 42-S Ignition System Tester Cylinder Leakdown Tester Oil Pressure Test Kit Rectifier-Regulator Tester (240 V AC/50Hz)	Kohler 25 761 42-S Kohler 25 455 01-S Kohler 25 761 05-S Kohler 25 761 06-S Kohler 25 761 41-S
Digital Vacuum/Pressure Tester For checking crankcase vacuum. Individual component available: Rubber Adapter Plug	Design Technology Inc. DTI-721-01 Design Technology Inc. DTI-721-10
Electronic Fuel Injection (EFI) Diagnostic Software For Laptop or Desktop PC.	Kohler 25 761 23-S
EFI Service Kit For troubleshooting and setting up an EFI engine. Components of 24 761 01-S Fuel Pressure Tester Noid Light 90° Adapter In-line "T" Fitting Code Plug, Red Wire Code Plug, Blue Wire Shrader Valve Adapter Hose	Kohler 24 761 01-S Design Technology Inc. DTI-019 DTI-021 DTI-023 DTI-035 DTI-027 DTI-029 DTI-037
Flywheel Puller For properly removing flywheel from engine.	SE Tools KLR-82408

TOOLS

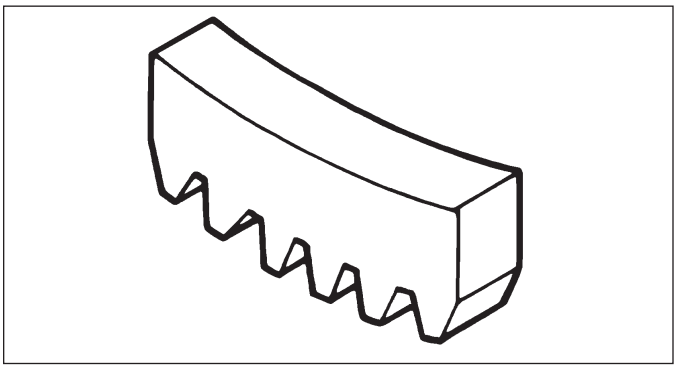
Description	Source/Part No.
Hydraulic Valve Lifter Tool For removing and installing hydraulic lifters.	Kohler 25 761 38-S
Ignition System Tester For testing output on all systems, including CD.	Kohler 25 455 01-S
Inductive Tachometer (Digital) For checking operating speed (RPM) of an engine.	Design Technology Inc. DTI-110
Offset Wrench (K and M Series) For removing and reinstalling cylinder barrel retaining nuts.	Kohler 52 455 04-S
Oil Pressure Test Kit For testing/verifying oil pressure on pressure lubricated engines.	Kohler 25 761 06-S
Rectifier-Regulator Tester (120 volt current) **Rectifier-Regulator Tester (240 volt current)** For testing rectifier-regulators. Components of 25 761 20-S and 25 761 41-S CS-PRO Regulator Test Harness Special Regulator Test Harness with Diode	Kohler 25 761 20-S Kohler 25 761 41-S Design Technology Inc. DTI-031 DTI-033
Spark Advance Module (SAM) Tester For testing SAM (ASAM and DSAM) on engines with SMART-SPARK™.	Kohler 25 761 40-S
Starter Servicing Kit (All Starters) For removing and reinstalling drive retaining rings and brushes. Individual component available: Starter Brush Holding Tool (Solenoid Shift)	SE Tools KLR-82411 SE Tools KLR-82416
Triad/OHC Timing Tool Set For holding cam gears and crankshaft in timed position while installing timing belt.	Kohler 28 761 01-S
Valve Guide Reamer (K and M Series) For properly sizing valve guides after installation.	Design Technology Inc. DTI-K828
Valve Guide Reamer O.S. (Command Series) For reaming worn valve guides to accept replacement oversize valves. Can be used in low-speed drill press or with handle below for hand reaming.	Kohler 25 455 12-S
Reamer Handle For hand reaming using Kohler 25 455 12-S reamer.	Design Technology Inc. DTI-K830

AIDS

Description	Source/Part No.
Camshaft Lubricant (Valspar ZZ613)	Kohler 25 357 14-S
Dielectric Grease (GE/Novaguard G661)	Kohler 25 357 11-S
Dielectric Grease	Loctite® 51360
Kohler Electric Starter Drive Lubricant (Inertia Drive)	Kohler 52 357 01-S
Kohler Electric Starter Drive Lubricant (Solenoid Shift)	Kohler 52 357 02-S
RTV Silicone Sealant Loctite® 5900® Heavy Body in 4 oz. aerosol dispenser. Only oxime-based, oil resistant RTV sealants, such as those listed, are approved for use. Loctite® Nos. 5900® or 5910® are recommended for best sealing characteristics.	Kohler 25 597 07-S Loctite® 5910® Loctite® Ultra Black 598™ Loctite® Ultra Blue 587™ Loctite® Ultra Copper 5920™
Spline Drive Lubricant	Kohler 25 357 12-S

Tools and Aids

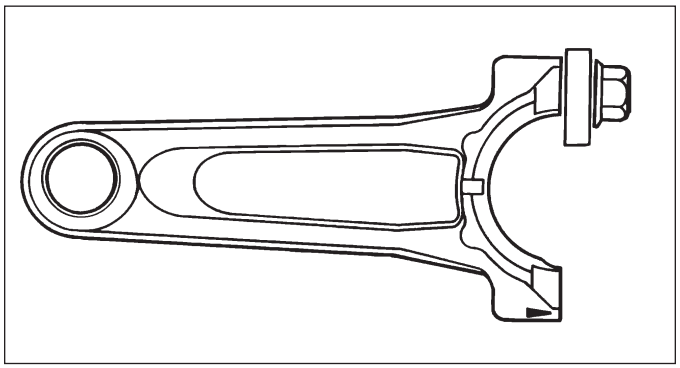
FLYWHEEL HOLDING TOOL



A flywheel holding tool can be made out of an old junk flywheel ring gear and used in place of a strap wrench.

1. Using an abrasive cut-off wheel, cut out a six tooth segment of ring gear as shown.
2. Grind off any burrs or sharp edges.
3. Invert segment and place it between ignition bosses on crankcase so tool teeth engage flywheel ring gear teeth. Bosses will lock tool and flywheel in position for loosening, tightening, or removing with a puller.

ROCKER ARM/CRANKSHAFT TOOL



A spanner wrench to lift rocker arms or turn crankshaft may be made out of an old junk connecting rod.

1. Find a used connecting rod from a 10 HP or larger engine. Remove and discard rod cap.
2. Remove studs of a Posi-Lock rod or grind off aligning steps of a Command rod, so joint surface is flat.
3. Find a 1 in. long capscrew with correct thread size to match threads in connecting rod.
4. Use a flat washer with correct I.D. to slip on capscrew and approximately 1 in. O.D**.** Assemble capscrew and washer to joint surface of rod.

TROUBLESHOOTING GUIDE

When troubles occur, be sure to check simple causes which, at first, may seem too obvious to be considered. For example, a starting problem could be caused by an empty fuel tank.

Some general common causes of engine troubles are listed below and vary by engine specification. Use these to locate causing factors.

Engine Cranks But Will Not Start

- Battery connected backwards.
- Blown fuse.
- Carburetor solenoid malfunction.
- Choke not closing.
- Clogged fuel line or fuel filter.
- Diode in wiring harness failed in open circuit mode.
- DSAI or DSAM malfunction.
- Empty fuel tank.
- Faulty electronic control unit.
- Faulty ignition coil(s).
- Faulty spark plug(s).
- Fuel pump malfunction-vacuum hose clogged or leaking.
- Fuel shut-off valve closed.
- Ignition module(s) faulty or improperly gapped.
- Insufficient voltage to electronic control unit.
- Interlock switch is engaged or faulty.
- Key switch or kill switch in OFF position.
- Low oil level.
- Quality of fuel (dirt, water, stale, mixture).
- SMART-SPARK$_{TM}$ malfunction.
- Spark plug lead(s) disconnected.

Engine Starts But Does Not Keep Running

- Faulty carburetor.
- Faulty cylinder head gasket.
- Faulty or misadjusted choke or throttle controls.
- Fuel pump malfunction-vacuum hose clogged or leaking.
- Intake system leak.
- Loose wires or connections that intermittently ground ignition kill circuit.
- Quality of fuel (dirt, water, stale, mixture).
- Restricted fuel tank cap vent.

Engine Starts Hard

- Clogged fuel line or fuel filter.
- Engine overheated.
- Faulty ACR mechanism.
- Faulty or misadjusted choke or throttle controls.
- Faulty spark plug(s).
- Flywheel key sheared.
- Fuel pump malfunction-vacuum hose clogged or leaking.
- Interlock switch is engaged or faulty.
- Loose wires or connections that intermittently ground ignition kill circuit.
- Low compression.
- Quality of fuel (dirt, water, stale, mixture).
- Weak spark.

Engine Will Not Crank

- Battery is discharged.
- Faulty electric starter or solenoid.
- Faulty key switch or ignition switch.
- Interlock switch is engaged or faulty.
- Loose wires or connections that intermittently ground ignition kill circuit.
- Pawls not engaging in drive cup.
- Seized internal engine components.

Engine Runs But Misses

- Carburetor adjusted incorrectly.
- Engine overheated.
- Faulty spark plug(s).
- Ignition module(s) faulty or improperly gapped.
- Incorrect crankshaft position sensor air gap.
- Interlock switch is engaged or faulty.
- Loose wires or connections that intermittently ground ignition kill circuit.
- Quality of fuel (dirt, water, stale, mixture).
- Spark plug lead(s) disconnected.
- Spark plug lead boot loose on plug.
- Spark plug lead loose.

Engine Will Not Idle

- Engine overheated.
- Faulty spark plug(s).
- Idle fuel adjusting needle(s) improperly set.
- Idle speed adjusting screw improperly set.
- Inadequate fuel supply.
- Low compression.
- Quality of fuel (dirt, water, stale, mixture).
- Restricted fuel tank cap vent.

Engine Overheats

- Cooling fan broken.
- Excessive engine load.
- Fan belt failed/off.
- Faulty carburetor.
- High crankcase oil level.
- Lean fuel mixture.
- Low cooling system fluid level.
- Low crankcase oil level.
- Radiator, and/or cooling system components clogged, restricted, or leaking.
- Water pump belt failed/broken.
- Water pump malfunction.

Engine Knocks

- Excessive engine load.
- Hydraulic lifter malfunction.
- Incorrect oil viscosity/type.
- Internal wear or damage.
- Low crankcase oil level.
- Quality of fuel (dirt, water, stale, mixture).

Engine Loses Power

- Dirty air cleaner element.
- Engine overheated.
- Excessive engine load.
- Restricted exhaust.
- Faulty spark plug(s).
- High crankcase oil level.
- Incorrect governor setting.
- Low battery.
- Low compression.
- Low crankcase oil level.
- Quality of fuel (dirt, water, stale, mixture).

Engine Uses Excessive Amount of Oil

- Loose or improperly torqued fasteners.
- Blown head gasket/overheated.
- Breather reed broken.
- Clogged, broken, or inoperative crankcase breather.
- Crankcase overfilled.
- Incorrect oil viscosity/type.
- Worn cylinder bore.
- Worn or broken piston rings.
- Worn valve stems/valve guides.

Oil Leaks from Oil Seals, Gaskets

- Breather reed broken.
- Clogged, broken, or inoperative crankcase breather.
- Loose or improperly torqued fasteners.
- Piston blow by, or leaky valves.
- Restricted exhaust.

EXTERNAL ENGINE INSPECTION

NOTE: It is good practice to drain oil at a location away from workbench. Be sure to allow ample time for complete drainage.

Before cleaning or disassembling engine, make a thorough inspection of its external appearance and condition. This inspection can give clues to what might be found inside engines (and cause) when it is disassembled.

- Check for buildup of dirt and debris on crankcase, cooling fins, grass screen, and other external surfaces. Dirt or debris on these areas can cause overheating.
- Check for obvious fuel and oil leaks, and damaged components. Excessive oil leakage can indicate a clogged or inoperative breather, worn or damaged seals or gaskets, or loose fasteners.
- Check air cleaner cover and base for damage or indications of improper fit and seal.
- Check air cleaner element. Look for holes, tears, cracked or damaged sealing surfaces, or other damage that could allow unfiltered air into engine. A dirty or clogged element could indicate insufficient or improper maintenance.
- Check carburetor throat for dirt. Dirt in throat is further indication that air cleaner was not functioning properly.
- Check if oil level is within operating range on dipstick. If it is above, sniff for gasoline odor.
- Check condition of oil. Drain oil into a container; it should flow freely. Check for metal chips and other foreign particles.

  Sludge is a natural by-product of combustion; a small accumulation is normal. Excessive sludge formation could indicate over rich fuel settings, weak ignition, overextended oil change interval or wrong weight or type of oil was used.

CLEANING ENGINE

	⚠ WARNING
	Cleaning Solvents can cause severe injury or death. Use only in well ventilated areas away from ignition sources.
Carburetor cleaners and solvents are extremely flammable. Follow cleaner manufacturer's warnings and instructions on its proper and safe use. Never use gasoline as a cleaning agent.	

After inspecting external condition of engine, clean engine thoroughly before disassembly. Clean individual components as engine is disassembled. Only clean parts can be accurately inspected and gauged for wear or damage. There are many commercially available cleaners that will quickly remove grease, oil, and grime from engine parts. When such a cleaner is used, follow manufacturer's instructions and safety precautions carefully.

Make sure all traces of cleaner are removed before engine is reassembled and placed into operation. Even small amounts of these cleaners can quickly break down lubricating properties of engine oil.

CRANKCASE VACUUM TEST

⚠ WARNING

Carbon Monoxide can cause severe nausea, fainting or death.

Avoid inhaling exhaust fumes.

Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled.

⚠ WARNING

Rotating Parts can cause severe injury.

Stay away while engine is in operation.

Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate engine with covers, shrouds, or guards removed.

A partial vacuum should be present in crankcase when engine is operating. Pressure in crankcase (normally caused by a clogged or improperly assembled breather) can cause oil to be forced out at oil seals, gaskets, or other available spots.

Crankcase vacuum is best measured with either a water manometer or a vacuum gauge. Complete instructions are provided in kits.

To test crankcase vacuum with manometer:

1. Insert rubber stopper into oil fill hole. Be sure pinch clamp is installed on hose and use tapered adapters to connect hose between stopper and one manometer tube. Leave other tube open to atmosphere. Check that water level in manometer is at 0 line. Make sure pinch clamp is closed.
2. Start engine and run no-load high speed.
3. Open clamp and note water level in tube.

   Level in engine side should be a minimum of 10.2 cm (4 in.) above level in open side.

   If level in engine side is less than specified (low/no vacuum), or level in engine side is lower than level in open side (pressure), check for conditions in table below.
4. Close pinch clamp before stopping engine.

To test crankcase vacuum with vacuum/pressure gauge:

1. Remove dipstick or oil fill plug/cap.
2. Install adapter into oil fill/dipstick tube opening, upside down over end of a small diameter dipstick tube, or directly into engine if a tube is not used. Insert barbed gauge fitting into hole in stopper.
3. Run engine and observe gauge reading.

   Analog tester–needle movement to left of 0 is a vacuum, and movement to right indicates a pressure.

   Digital tester–depress test button on top of tester.

   Crankcase vacuum should be a minimum of 10.2 cm (4 in.) of water. If reading is below specification, or if pressure is present, check table below for possible causes and conclusions.

Condition	Conclusion
Crankcase breather clogged or inoperative.	NOTE: If breather is integral part of valve cover and cannot be serviced separately, replace valve cover and recheck pressure. Disassemble breather, clean parts thoroughly, check sealing surfaces for flatness, reassemble, and recheck pressure.
Seals and/or gaskets leaking. Loose or improperly torque fasteners.	Replace all worn or damaged seals and gaskets. Make sure all fasteners are tightened securely. Use appropriate torque valves and sequences when necessary.
Piston blow by or leaky valves (confirm by inspecting components).	Recondition piston, rings, cylinder bore, valves and valves guides.
Restricted exhaust.	Check exhaust screen/spark arrestor (if equipped). Clean or replace as needed. Repair or replace any other damaged/restricted muffler or exhaust system parts.

COMPRESSION TEST

For Command Twins:

A compression test is best performed on a warm engine. Clean any dirt or debris away from base of spark plug(s) before removing them. Be sure choke is off, and throttle is wide open during test. Compression should be at least 160 psi and should not vary more than 15% between cylinders.

All other models:

These engines are equipped with an automatic compression release (ACR) mechanism. It is difficult to obtain an accurate compression reading because of ACR mechanism. As an alternative, use cylinder leakdown test described below.

CYLINDER LEAKDOWN TEST

A cylinder leakdown test can be a valuable alternative to a compression test. By pressurizing combustion chamber from an external air source you can determine if valves or rings are leaking, and how badly.

Cylinder leakdown tester is a relatively simple, inexpensive leakdown tester for small engines. This tester includes a quick-connect for attaching adapter hose and a holding tool.

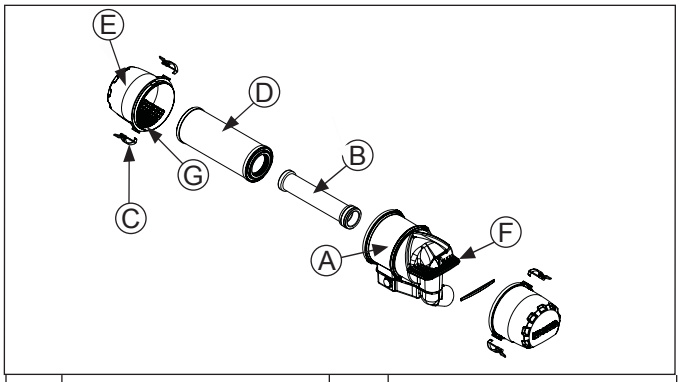
1. Run engine for 3-5 minutes to warm it up.
2. Remove spark plug(s) and air filter from engine.
3. Rotate crankshaft until piston (of cylinder being tested) is at top dead center (TDC) of compression stroke. Hold engine in this position while testing. Holding tool supplied with tester can be used if PTO end of crankshaft is accessible. Lock holding tool onto crankshaft. Install a 3/8 in. breaker bar into hole/slot of holding tool, so it is perpendicular to both holding tool and crankshaft PTO.

   If flywheel end is more accessible, use a breaker bar and socket on flywheel nut/screw to hold it in position. An assistant may be needed to hold breaker bar during testing. If engine is mounted in a piece of equipment, it may be possible to hold it by clamping or wedging a driven component. Just be certain that engine cannot rotate off of TDC in either direction.
4. Install adapter into spark plug hole, but do not attach it to tester at this time.
5. Turn regulator knob completely counterclockwise.
6. Connect an air source of at least 50 psi to tester.
7. Turn regulator knob clockwise (increase direction) until gauge needle is in yellow set area at low end of scale.
8. Connect tester quick-connect to adapter hose. While firmly holding engine at TDC, gradually open tester valve. Note gauge reading and listen for escaping air at combustion air intake, exhaust outlet, and crankcase breather.

Condition	Conclusion
Air escaping from crankcase breather.	Ring or cylinder worn.
Air escaping from exhaust system.	Defective exhaust valve/improper seating.
Air escaping from intake.	Defective intake valve/improper seating.
Gauge reading in low (green) zone.	Piston rings and cylinder in good condition.
Gauge reading in moderate (yellow) zone.	Engine is still usable, but there is some wear present. Customer should start planning for overhaul or replacement.
Gauge reading in high (red) zone.	Rings and/or cylinder have considerable wear. Engine should be reconditioned or replaced.

AIR CLEANER

These systems are CARB/EPA certified and components should not be altered or modified in any way.



A	Air Cleaner Housing	**B**	Inner Element (if equipped)
C	Retaining Clip	**D**	Element
E	End Cap	**F**	Inlet Screen
G	Ejector Area		

NOTE: Operating engine with loose or damaged air cleaner components could cause premature wear and failure. Replace all bent or damaged components.

NOTE: Paper element cannot be blown out with compressed air.

1. Unhook retaining clips and remove end cap(s).
2. Check and clean inlet screen (if equipped).
3. Pull air cleaner element out of housing and replace. Check condition of inner element (if equipped); replace when dirty.
4. Check all parts for wear, cracks, or damage, and that ejector area is clean.
5. Install new element(s).
6. Reinstall end cap(s) with dust ejector valve/screen down; secure with retaining clips.

BREATHER TUBE

Ensure both ends of breather tube are properly connected.

AIR COOLING

	⚠ WARNING
	Hot Parts can cause severe burns. Do not touch engine while operating or just after stopping.
Never operate engine with heat shields or guards removed.	

NOTE: Operating engine with a restricted air intake screen or radiator, damaged/ broken fan assembly, or missing fan shroud will cause engine damage due to over heating.

Proper cooling is essential. To prevent over heating, clean screens, cooling fins, and other external surfaces of engine. Avoid spraying water at wiring harness or any electrical components. See Maintenance Schedule.

EFI SYSTEM

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Do not fill fuel tank while engine is hot or running.

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.

Typical electronic fuel injection (EFI) system and related components include:

- Fuel pump module and lift pump.
- Fuel filter.
- High pressure fuel line.
- Fuel line(s).
- Fuel injectors.
- Throttle body/intake manifold.
- Electronic control unit (ECU).
- Ignition coils.
- Engine (oil) temperature sensor.
- Throttle position sensor (TPS).
- Crankshaft position sensor.
- Oxygen sensor.
- Temperature/Manifold Air Pressure (TMAP) sensor.
- Wire harness assembly & affiliated wiring.
- Malfunction indicator light (MIL) - optional.

FUEL RECOMMENDATIONS

Refer to Maintenance.

FUEL LINE

Low permeation fuel line must be installed on all Kohler Co. engines to maintain EPA and CARB regulatory compliance.

OPERATION

NOTE: When performing voltage or continuity tests, avoid putting excessive pressure on or against connector pins. Flat pin probes are recommended for testing to avoid spreading or bending terminals.

EFI system is designed to provide peak engine performance with optimum fuel efficiency and lowest possible emissions. Ignition and injection functions are electronically controlled, monitored and continually corrected during operation to maintain ideal air/fuel ratio.

Central component of system is Engine Control Unit (ECU) which manages system operation, determining best combination of fuel mixture and ignition timing for current operating conditions.

A lift fuel pump is used to move fuel from tank through an in-line fuel filter and fuel line. Fuel is then pumped to fuel pump module. Fuel pump module regulates fuel pressure to a system operating pressure of 39 psi. Fuel is delivered from fuel pump module through high pressure fuel line into injectors, which inject fuel into intake ports. ECU controls amount of fuel by varying length of time that injectors are on. This can range from 2 to over 12 milliseconds depending on fuel requirements. Controlled injection of fuel occurs every other crankshaft revolution, or once for each 4-stroke cycle. When intake valve opens, air/fuel mixture is drawn into combustion chamber,compressed, ignited, and burned.

ECU controls amount of fuel being injected and ignition timing by monitoring primary sensor signals for engine temperature, speed (RPM), and throttle position (load). These primary signals are compared to preprogrammed maps in ECU computer chip, and ECU adjusts fuel delivery to match mapped values. After engine reaches operating temperature, an exhaust gas oxygen sensor provides feedback to ECU based upon amount of unused oxygen in exhaust, indicating whether fuel mixture being delivered is rich or lean. Based upon this feedback, ECU further adjusts fuel input to re-establish ideal air/fuel ratio. This operating mode is referred to as closed loop operation. EFI system operates closed loop when all three of following conditions are met:

- Oil temperature is greater than 50°C (122°F).
- Oxygen sensor has warmed sufficiently to provide a signal (minimum 400°C, 752°F).
- Engine operation is at a steady state (not starting, warming up, accelerating, etc.).

During closed loop operation ECU has ability to readjust temporary and learned adaptive controls, providing compensation for changes in overall engine condition and operating environment, so it will be able to maintain ideal air/fuel ratio. This system requires a minimum engine oil temperature of 60°-70°C (140°-158°F) to properly adapt. These adaptive values are maintained as long as ECU is not reset.

During certain operating periods such as cold starts, warm up, acceleration, high load, etc., a richer air/fuel ratio is required and system operates in an open loop mode. In open loop operation oxygen sensor output is used to ensure engine is running rich, and controlling adjustments are based on primary sensor signals and programmed maps only. This system operates open loop whenever three conditions for closed loop operation (above) are not being met.

ECU is brain or central processing computer of entire EFI system. During operation, sensors continuously gather data which is relayed through wiring harness to input circuits within ECU. Signals to ECU include: ignition (on/off), crankshaft position and speed (RPM), throttle position, oil temperature, intake air temperature, exhaust oxygen levels, manifold absolute pressure, and battery voltage.

ECU compares input signals to programmed maps in its memory to determine appropriate fuel and spark requirements for immediate operating conditions. ECU then sends output signals to set injector duration and ignition timing.

ECU continually performs a diagnostic check of itself, each of sensors, and system performance. If a fault is detected, ECU can turn on a Malfunction Indicator Light (MIL) (if equipped) on equipment control panel, store fault code in its fault memory, and go into a default operating mode. Depending on significance or severity of fault, normal operation may continue. A technician can access stored fault code using a blink code diagnosis flashed out through MIL. An optional computer software diagnostic program is also available, see Tools and Aids.

ECU requires a minimum of 6.0 volts to operate.

To prevent engine over-speed and possible failure, a rev-limiting feature is programmed into ECU. If maximum RPM limit (4500) is exceeded, ECU suppresses injection signals, cutting off fuel flow. This process repeats itself in rapid succession, limiting operation to preset maximum.

Wiring harness used in EFI system connects electrical components, providing current and ground paths for system to operate. All input and output signaling occurs through two special all weather connectors that attach and lock to ECU. Connectors are Black and Grey and keyed differently to prevent being attached to ECU incorrectly.

Condition of wiring, connectors, and terminal connections is essential to system function and performance. Corrosion, moisture, and poor connections are as likely cause of operating problems and system errors as an actual component. Refer to Electrical System for additional information.

EFI system is a 12 VDC negative ground system, designed to operate down to a minimum of 6.0 volts. If system voltage drops below this level, operation of voltage sensitive components such as ECU, fuel pump, ignition coils, and injectors will be intermittent or disrupted, causing erratic operation or hard starting. A fully charged, 12 volt battery with a minimum of 350 cold cranking amps is important in maintaining steady and reliable system operation. Battery condition and state of charge should always be checked first when troubleshooting an operational problem.

Keep in mind that EFI-related problems are often caused by wiring harness or connections. Even small amounts of corrosion or oxidation on terminals can interfere with milliamp currents used in system operation.

Cleaning connectors and grounds will solve problems in many cases. In an emergency situation, simply disconnecting and reconnecting connectors may clean up contacts enough to restore operation, at least temporarily.

If a fault code indicates a problem with an electrical component, disconnect ECU connector and test for continuity between component connector terminals and corresponding terminals in ECU connector using an ohmmeter. Little or no resistance should be measured, indicating that wiring of that particular circuit is OK.

Crankshaft position sensor is essential to engine operation; constantly monitoring rotation and speed (RPM) of crankshaft. There are 23 consecutive teeth cast into flywheel. One tooth is missing and is used to reference crankshaft position for ECU.

During rotation, an AC voltage pulse is created within sensor for each passing tooth. ECU calculates engine speed from time interval between consecutive pulses. Gap from missing tooth creates an interrupted input signal, corresponding to specific crankshaft position near BDC for cylinder #1. This signal serves as a reference for control of ignition timing by ECU. Synchronization of inductive speed pickup and crankshaft position takes place during first two revolutions each time engine is started. Sensor must be properly connected at all times. If sensor becomes disconnected for any reason, engine will quit running.

Throttle position sensor (TPS) is used to indicate throttle plate angle to ECU. Since throttle (by way of governor) reacts to engine load, angle of throttle plate is directly related to load on engine.

Mounted on throttle body and operated directly off end of throttle shaft, TPS works as a potentiometer, varying voltage signal to ECU in direct correlation to angle of throttle plate. This signal, along with other sensor signals, is processed by ECU and compared to internal preprogrammed maps to determine required fuel and ignition settings for amount of load.

Correct position of TPS is established and set at factory. Do not loosen TPS or alter mounting position unless absolutely required by fault code diagnosis. If TPS is loosened or repositioned, appropriate TPS Learn Procedure must be performed to re-establish baseline relationship between ECU and TPS.

Engine (oil) temperature sensor is used by system to help determine fuel requirements for starting (a cold engine needs more fuel than one at or near operating temperature).

Mounted in oil pan near oil filter, it has a temperature-sensitive resistor that extends into oil flow. Resistance changes with oil temperature, altering voltage sent to ECU. Using a table stored in its memory, ECU correlates voltage drop to a specific temperature. Using fuel delivery maps, ECU then knows how much fuel is required for starting at that temperature.

Temperature/Manifold Air Pressure (TMAP) sensor is an integrated sensor that checks both intake air temperature and manifold absolute pressure.

Intake Air Temperature control is a thermally sensitive resistor that exhibits a change in electrical resistance with a change in its temperature. When sensor is cold, resistance of sensor is high. As sensor warms up, resistance drops and voltage signal increases. From voltage signal, ECU can determine temperature of intake air.

Purpose of sensing air temperature is to help ECU calculate air density. Higher air temperature less dense air becomes. As air becomes less dense ECU knows that it needs to lessen fuel flow to achieve correct air/fuel ratio. If fuel ratio was not changed engine would become rich, possibly losing power and consuming more fuel.

Manifold Absolute Pressure check provides immediate manifold pressure information to ECU. TMAP sensor measures difference in pressure between outside atmosphere and vacuum level inside intake manifold and monitors pressure in manifold as primary means of detecting load. Data is used to calculate air density and determine engine's mass air flow rate, which in turn determines required ideal fueling. TMAP also stores instant barometric pressure reading when key is turned ON.

Oxygen sensor functions like a small battery, generating a voltage signal to ECU based upon difference in oxygen content between exhaust gas and ambient air.

Tip of sensor, protruding into exhaust gas, is hollow. Outer portion of tip is surrounded by exhaust gas, with inner portion exposed to ambient air. When oxygen concentration on one side of tip is different than that of other side, a voltage signal up to 1.0 volt is generated and sent to ECU. Voltage signal tells ECU if engine is straying from ideal fuel mixture, and ECU then adjusts injector pulse accordingly.

Oxygen sensor functions after being heated to a minimum of 400°C (752°F). A heater inside sensor heats electrode to optimum temperature in about 10 seconds. Oxygen sensor receives ground through wire, eliminating need for proper grounding through muffler. If problems indicate a bad oxygen sensor, check all connections and wire harness. Oxygen sensor can also be contaminated by leaded fuel, certain RTV and/or other silicone compounds, fuel injector cleaners, etc. Use only those products indicated as O2 Sensor Safe.

Fuel injectors mount into intake manifold, and high pressure fuel line attaches to them at top end. Replaceable O-rings on both ends of injector prevent external fuel leakage and also insulate it from heat and vibration. A special clip connects each injector to high pressure fuel line and holds it in place. O-rings and retaining clip must be replaced any time fuel injector is separated from its normal mounting position.

When key switch is on, fuel pump module will pressurize high pressure fuel line to 39 psi, and voltage is present at injector. At proper instant, ECU completes ground circuit, energizing injector. Valve needle in injector is opened electromagnetically, and pressure in high pressure fuel line forces fuel down through inside. Director plate at tip of injector contains a series of calibrated openings which directs fuel into manifold in a cone-shaped spray pattern.

Injectors have sequential fueling that open and close once every other crankshaft revolution. Amount of fuel injected is controlled by ECU and determined by length of time valve needle is held open, also referred to as injection duration or pulse width. Time injector is open (milliseconds) may vary in duration depending on speed and load requirements of engine.

A high-voltage, solid-state, battery ignition system is used with EFI system. ECU controls ignition output and timing through transistorized control of primary current delivered to coils. Based on input from crankshaft position sensor, ECU determines correct firing point for speed at which engine is running. At proper instant, it interrupts flow of primary current in coil, causing electromagnetic flux field to collapse. Flux collapse induces an instantaneous high voltage in coil secondary which is strong enough to bridge gap on spark plug. Each coil fires every other revolution.

EFI engines are equipped with either a 20 or 25 amp charging system to accommodate combined electrical demands of ignition system and specific application. Charging system troubleshooting information is provided in Electrical System.

An electric fuel pump module and a lift pump are used to transfer fuel in EFI system. Pumping action is created by oscillation of positive and negative pressures within crankcase through a hose. Internal check valves prevent fuel from going backward through pump. Fuel pump module receives fuel from lift pump, increases and regulates pressure for fuel injectors.

Fuel pump module is rated for a minimum output of 13.5 liters per hour and regulated at 270 kilopascals (39 psi).

When key switch is turned ON and all safety switch requirements are met, ECU activates fuel pump module for about six seconds, which pressurizes system for start-up. If key switch is not promptly turned to start position, engine fails to start, or engine is stopped with key switch ON (as in case of an accident), ECU switches off pump preventing continued delivery of fuel. In this situation, MIL will go on, but it will go back off after 4 cranking revolutions if system function is OK. Once engine is running, fuel pump remains on.

Precision components inside fuel pump module are not serviceable. DO NOT attempt to open fuel pump module. Damage to components will result and warranty will be void. Because fuel pump module is not serviceable, engines are equipped with a special 10-micron EFI fuel filter to prevent harmful contamination from entering module.

If there are two filters in system, one before lift pump will be a standard 51-75 micron filter, and one after lift pump will be special 10-micron filter. Be sure to use an approved 10-micron filter for replacement.

High pressure fuel line is an assembly of hoses, injector caps and a fuel connector to fuel pump module. High pressure fuel line feeds fuel to top of injectors through injector caps. Caps are fastened to intake manifold and injectors are locked into place. A small retaining clip provides a secondary lock.

High pressure fuel line is serviced as a complete assembly to prevent tampering and safety hazards. Components are not individually serviceable.

Vent hose assembly is intended to vent fuel vapor out of fuel pump module and direct fuel vapor into throttle body. All EFI engines are equipped with an engine mounted purge port on #2 side of blower housing. This capped purge port can be used by OEM to vent fuel tanks or used in conjunction with a carbon canister kit for Tier III evaporative emissions compliance. Purge port connects to vent hose assembly and directs all fuel vapor into throttle body. If purge port remains unused, port must remain capped to prevent dirt from entering engine.

EFI engines have no carburetor, so throttle function (regulate incoming combustion airflow) is achieved with a throttle valve in a separate throttle body attached to intake manifold. Throttle body/intake manifold provides mounting for fuel injectors, throttle position sensor, TMAP sensor, high pressure fuel line, idle speed screw, and air cleaner assembly.

Idle speed is only adjustment that may be performed on EFI system. Standard idle speed setting for EFI engines is 1500 RPM, but certain applications might require a different setting. Check equipment manufacturer's recommendation.

For starting and warm up, ECU will adjust fuel and ignition timing, based upon ambient temperature, engine temperature, and loads present. In cold conditions, idle speed will probably be different than normal for a few moments. Under other conditions, idle speed may actually start lower than normal, but gradually increase to established setting as operation continues. Do not attempt to circumvent this warm up period, or readjust idle speed during this time. Engine must be completely warmed up, in closed loop operating mode for accurate idle adjustment.

IMPORTANT NOTES!

- Cleanliness is essential and must be maintained at all times when servicing or working on EFI system. Dirt, even in small quantities, can cause significant problems.
- Clean any joint or fitting with parts cleaning solvent before opening to prevent dirt from entering system.
- Always depressurize fuel system through fuel connector on fuel pump module before disconnecting or servicing any fuel system components.
- Never attempt to service any fuel system component while engine is running or ignition switch is ON.
- Do not use compressed air if system is open. Cover any parts removed and wrap any open joints with plastic if they will remain open for any length of time. New parts should be removed from their protective packaging just prior to installation.
- Avoid direct water or spray contact with system components.
- Do not disconnect or reconnect ECU wiring harness connector or any individual components with ignition on. This can send a damaging voltage spike through ECU.
- Do not allow battery cables to touch opposing terminals. When connecting battery cables attach positive (+) cable to positive (+) battery terminal first, followed by negative (-) cable to negative (-) battery terminal.
- Never start engine when cables are loose or poorly connected to battery terminals.
- Never disconnect battery while engine is running.
- Never use a quick battery charger to start engine.
- Do not charge battery with key switch ON.
- Always disconnect negative (-) battery cable before charging battery, and also unplug harness from ECU before performing any welding on equipment.

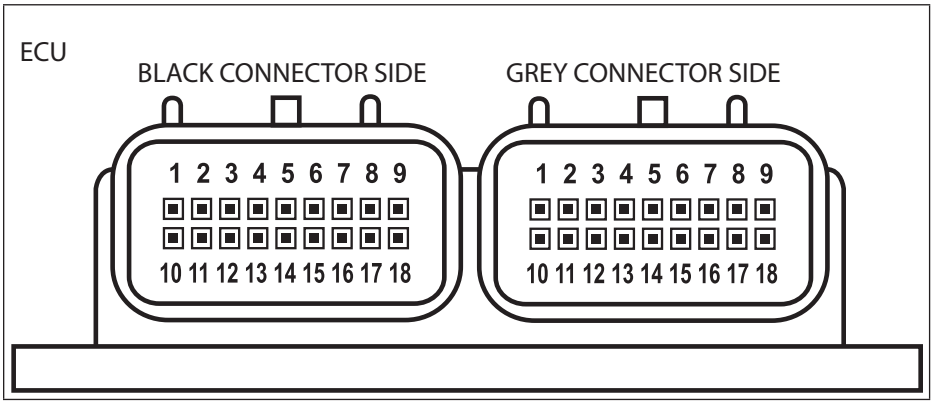
ELECTRICAL COMPONENTS

Electronic Control Unit (ECU)

Pinout of ECU

Black Connector Side	
Pin #	**Function**
1	Ignition Coil #1 Ground
2	Battery Ground
3	Diagnostic Communication Line
4	Speed Sensor input
5	Fuel Injector Output #1 Ground
6	Fuel Injector Output #2 Ground
7	Oxygen Sensor Heater
8	Intake Air Temperature (TMAP) sensor input
9	Fuel Pump Ground
10	Ground for TPS, TMAP, O2 and Oil Sensors
11	Manifold Absolute Pressure (TMAP) sensor input
12	Throttle Position Sensor (TPS) input
13	Speed Sensor Ground
14	Oil Temperature Sensor input
15	Ignition Switch (Switched +12V)
16	Power for TPS and TMAP Sensors (+5V)
17	Oxygen Sensor (O2) input
18	Battery Power (Permanent +12V)

Grey Connector Side	
Pin #	**Description**
1	Not Used
2	Not Used
3	Malfunction Indicator Light (MIL) Ground
4	Not Used
5	Not Used
6	GCU Tach Output
7	Not Used
8	Not Used
9	Battery Ground
10	Ignition Coil #2 Ground
11	Not Used
12	Not Used
13	Not Used
14	Safety Switch Ground
15	Not Used
16	ECU
17	Fuel Pump Control (+12V)
18	Not Used



Pinout of ECU

Never attempt to disassemble ECU. It is sealed to prevent damage to internal components. Warranty is void if case is opened or tampered with in any way.

All operating and control functions within ECU are preset. No internal servicing or readjustment may be performed. If a problem is encountered, and you determine ECU to be faulty, contact your source of supply.

ECU pins are coated at factory with a thin layer of electrical grease to prevent fretting and corrosion. Do not attempt to remove grease from ECU pins.

Relationship between ECU and throttle position sensor (TPS) is very critical to proper system operation. If TPS or ECU is changed, or mounting position of TPS is altered, appropriate TPS Learn Procedure must be performed to restore synchronization.

Any service to ECU, TPS/Throttle Body (including idle speed increase over 300 RPM), or fuel pump module replacement should include ECU Reset.

This will clear all trouble codes, all closed loop learned offsets, all max values, and all timers besides permanent hour meter.

This system will NOT reset when battery is disconnected!

ECU Reset Procedure

1. Turn key/ignition OFF.
2. Install Red wire jumper from Kohler EFI service kit on to service port (connect white wire to black wire in 4 way diagnostic port).
3. Turn key/ignition ON, then OFF and count 10 seconds.
4. Turn key/ignition ON, then OFF and count to 10 seconds a second time.
5. Remove Red wire jumper. Turn key/ignition ON, then OFF and count to 10 seconds a third time. ECU is reset.

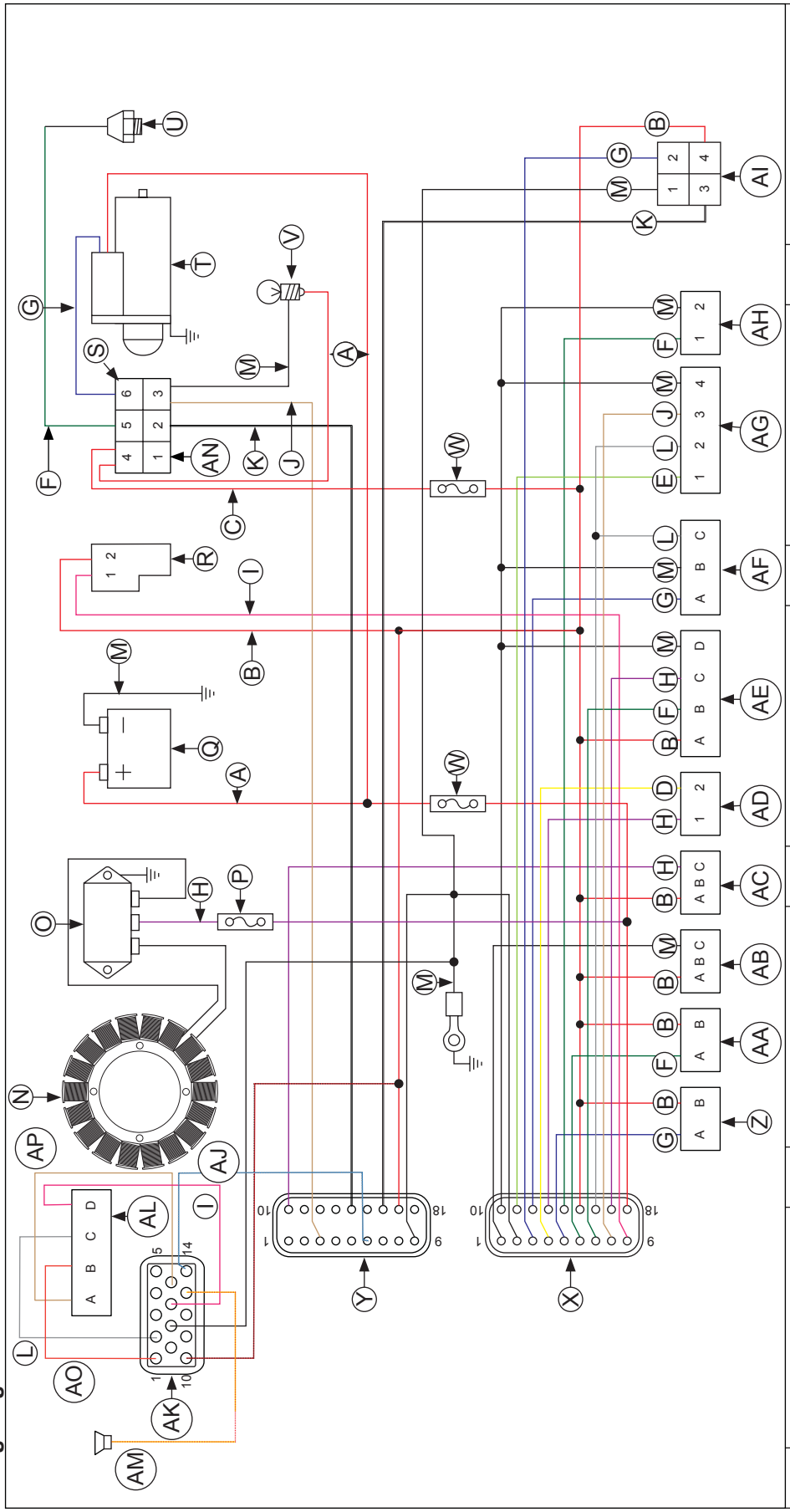
A TPS Learn Procedure **must** be performed after ECU Reset.

TPS Learn Procedure

1. Turn idle screw clockwise one full turn prior to key/ignition ON after ECU Reset.
2. Start engine, run at low idle until engine is warm.
3. Idle speed must be above 1500 RPM. If below 1500 RPM, turn idle screw up to 1700 RPM and then shut down engine and perform ECU Reset again.
4. Restart engine, adjust idle speed down to 1500 RPM. Allow engine to dwell at 1500 RPM for about 3 seconds.
5. After this, adjust idle speed to final specified speed setting.
6. Turn key/ignition OFF and count to 10 seconds.

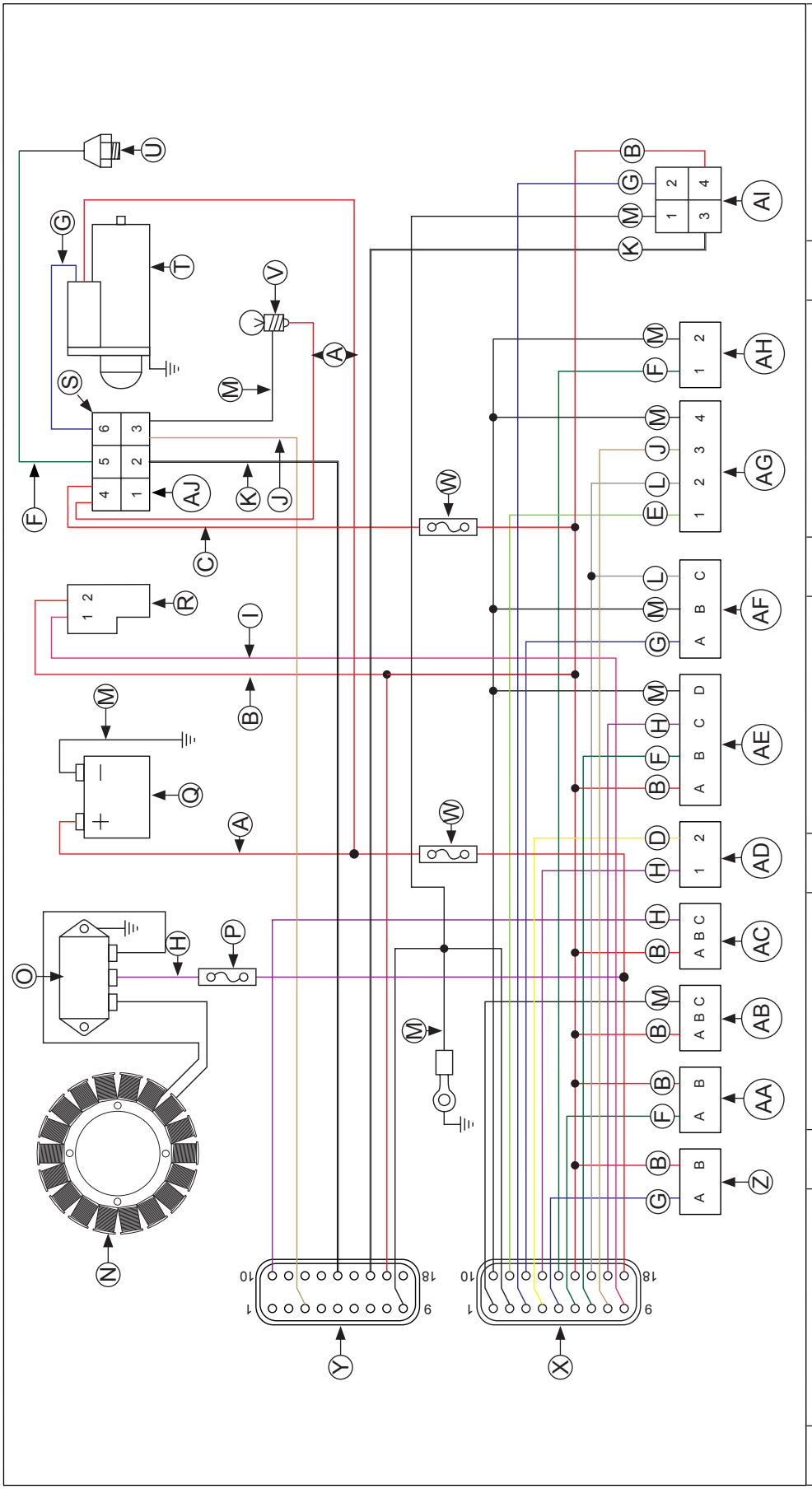
Learn procedure is complete.

Wiring Diagram Electronic Governor



A	Red	B	Red/Black	C	Red/White	D	Yellow	E	Light Green
F	Dark Green	G	Dark Blue	H	Purple	I	Pink	J	Tan
K	White	L	Grey	M	Black	N	Stator	O	Rectifier-Regulator
P	30A Fuse	Q	Battery	R	Fuel Pump	S	6-Terminal Connector	T	Starter Motor
U	Oil Pressure Switch	V	MIL	W	10A Fuse	X	Black Connector	Y	Grey Connector
Z	Fuel Injector #1	AA	Fuel Injector #2	AB	Ignition Coil #1	AC	Ignition Coil #2	AD	Crankshaft Position Sensor
AE	Oxygen Sensor	AF	Throttle Position Sensor	AG	TMAP Sensor	AH	EFI Oil Temperature Sensor	AI	Diagnostic Connector
AJ	Grey/Blue	AK	Electronic Governor Module	AL	Stepper Motor	AM	Red/Yellow Wire	AN	Oil Temperature Sensor (some models)
AO	Orange	AP	Brown						

Wiring Diagram Mechanical Governor



A	Red	B	Red/Black	C	Red/White	D	Yellow	E	Light Green
F	Dark Green	G	Dark Blue	H	Purple	I	Pink	J	Tan
K	White	L	Grey	M	Black	N	Stator	O	Rectifier-Regulator
P	30A Fuse	Q	Battery	R	Fuel Pump	S	6-Terminal Connector	T	Starter Motor
U	Oil Pressure Switch	V	MIL	W	10A Fuse	X	Black Connector	Y	Grey Connector
Z	Fuel Injector #1	AA	Fuel Injector #2	AB	Ignition Coil #1	AC	Ignition Coil #2	AD	Crankshaft Position Sensor
AE	Oxygen Sensor	AF	Throttle Position Sensor	AG	TMAP Sensor	AH	EFI Oil Temperature Sensor	AI	Diagnostic Connector
AJ	Oil Temperature Sensor (some models								

Crankshaft Position Sensor

A sealed, non-serviceable assembly. If Fault Code diagnosis indicates a problem within this area, test and correct as follows.

1. Remove #2 cylinder clean-out cover from blower housing to access. Check sensor mounting.
2. Inspect wiring and connections for damage or problems.
3. Make sure engine has resistor type spark plugs.
4. Disconnect Black connector from ECU.
5. Connect an ohmmeter between #4 and #13 pin terminals. A resistance value of 325-395 Ω at room temperature (20°C, 68°F) should be obtained. If resistance is correct, check mounting, flywheel teeth (damage, run-out, etc.), and flywheel key.
6. Disconnect crankshaft position sensor connector from wiring harness. Test resistance between terminals. A reading of 325-395 Ω should again be obtained.
   a. If resistance is incorrect, remove screw securing sensor to crankcase and replace sensor. Follow procedures in Disassembly to remove blower housing.
   b. If resistance in step 5 was incorrect, but resistance of sensor alone was correct, test wire harness circuits between sensor connector terminals and corresponding pin terminals (#4 and #13) in main connector. Correct any observed problem, reconnect sensor, and perform step 5 again.
7. When fault is corrected and engine starts, clear fault codes following ECU Reset procedure.

Throttle Position Sensor (TPS)

TPS is a sealed, non-serviceable assembly. If diagnosis indicates a bad sensor, complete replacement is necessary. A magnet that sensor detects is separate, and can be replaced or reused. If a blink code indicates a problem with TPS, it can be tested as follows:

Diagnostics of sensor: ECU will have electrical faults captured in fault codes P0122 and P0123. Fault code P0122 detecting low voltage, open circuit, and P0123 for high voltage conditions between ECU, wire harness, and sensor. Tip: when working with any electrical connection, remember to keep connections clean & dry. This is best accomplished by cleaning connection thoroughly prior to disassembly. Contaminated sensor connections can cause premature engine faults. Functionally testing sensor can no longer be done with simple resistance checks. If either of these two faults is present or a TPS fault is suspected, recommended diagnostic test is as follows:

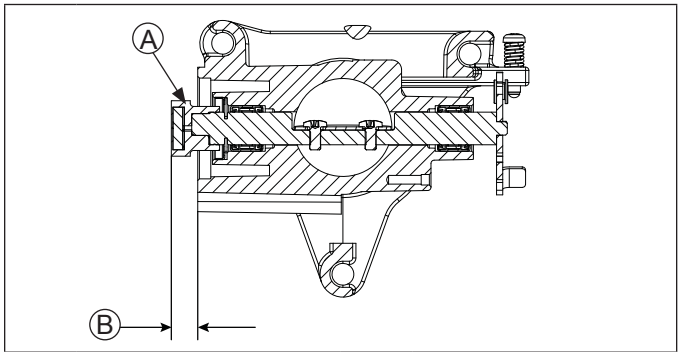
If a computer with diagnostic software is available

Observe throttle percent and raw TPS values through diagnostic software. With diagnostic software communicating to ECU and key ON engine not running, these values can be observed while throttle is moved from closed to full open position. There should be a smooth and repeatable throttle percent value starting at closed position reading between 0 (about 6.5%) to WOT position reading 93 (100%). If one of these values is outside of specified range and output transitions in a smooth manner, reset ECU and run test again. Since there is no longer any wear elements inside sensor, most likely faults will be in electrical connections between sensor and wire harness and wire harness to ECU. With service software communicating to ECU and engine not running, a small load or gentle back and forth motion can be applied to connectors or wires just outside connectors to detect a faulty connection.

If only a volt meter is available

Measure voltage supply to sensor from ECU. This voltage should be 5.00 +/- 0.20 volts. This can be measured by gently probing terminals B & C on harness side with TPS connector removed from TPS and key ON. This will generate a P0122 fault that can be cleared with an ECU reset. If voltage is low, battery, harness and ECU should be investigated. If supply voltage is good, plug sensor back into harness. Probe sensor signal wire with volt meter, terminal A at TPS or pin Black 12 at ECU. This signal should start between 0.6-1.2 volts at low idle and grow smoothly as throttle is opened to 4.3-4.8 volts at full open (WOT). Since there is no longer any wear elements inside sensor, most likely faults will be in electrical connections between sensor and wire harness and wire harness to ECU.

Replace magnet assembly



A	Magnet Assembly	**B**	Magnet Installation Depth

Magnet assembly is captured in a small plastic housing that is press fit to end of throttle shaft. This generally does not need replacement. If replacement is required, it can be replaced as follows:

1. Remove sensor from throttle body, exposing round magnet assembly.
2. A pair of flat blade screw drivers or a spanner tool can be used to pry this off shaft. Caution should be used to avoid damage to machined flat surface that sensor seals against. Also, make sure throttle blade is in full open position to avoid driving throttle blade into throttle bore causing damage to blade and/or bore.
3. When replacing magnet assembly, alignment is critical. There is a D-shaped drive feature on end of shaft and a matching pocket in magnet assembly. On outer diameter of magnet assembly is a notch that aligns with center of flat feature of D. Align this notch and flat of D feature in shaft and preassemble parts.

4. With throttle blade in full open position (WOT), press magnet assembly fully on to throttle shaft. Full insertion can be checked by measuring height from throttle body sensor mounting face to end of magnet assembly. This should be no more than 8.6 mm (0.338 in). Installation process requires significant force, so take care that all parts are aligned. Tapping magnet assembly on can fracture/damage brittle magnet within assembly and throttle body assembly and is NOT RECOMMENDED.

Engine (Oil) Temperature Sensor

A sealed, non-serviceable assembly. A faulty sensor must be replaced. If a blink code indicates a problem with temperature sensor, it can be tested as follows:

1. Remove temperature sensor from crankcase and cap or block sensor hole.
2. Wipe sensor clean and allow it to reach room temperature (25°C, 77°F).
3. Unplug Black connector from ECU.
4. With sensor still connected, check temperature sensor circuit resistance between Black pin 10 and 14 terminals. Value should be 9000-11000 Ω.
5. Unplug sensor from wire harness and check sensor resistance separately across two pins. Resistance value should again be 9000-11000 Ω.
   a. If resistance is out of specifications, replace temperature sensor.
   b. If it is within specifications, proceed to Step 6.
6. Check circuits (input, ground), from wire harness connector to sensor plug for continuity, damage, etc. Connect one ohmmeter lead to Black pin 14 in wire harness connector (as in step 4). Connect other lead to terminal #1 in sensor plug. Continuity should be indicated. Repeat test between Black pin 10 and terminal #2 in sensor plug.

Temperature/Manifold Air Pressure (TMAP) Sensor

A sealed non-serviceable integrated sensor that checks both intake air temperature and manifold absolute pressure. Complete replacement is required if it is faulty. Sensor and wiring harness can be checked as follows.

If a blink code indicates a problem with Intake Air Temperature (TMAP) Sensor Circuit (P0112 or P0113), it can be tested as follows:

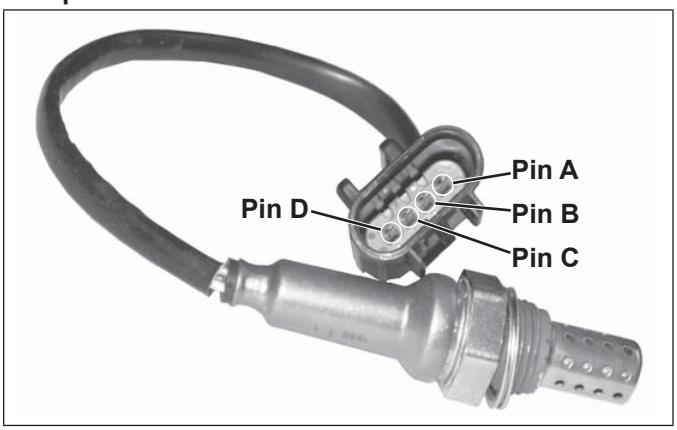
1. Remove TMAP sensor from intake manifold.
2. Allow it to reach room temperature (20°C, 68°F).
3. Unplug Black connector from ECU.
4. With sensor still connected, check temperature sensor circuit resistance between Black pin 10 and 8 pin terminals. Value should be 1850-2450 Ω.
5. Unplug sensor from wire harness and check sensor resistance separately across pin. Resistance value should again be 1850-2450 Ω.
   a. If resistance is out of specifications, check local temperature. Sensor resistance will go down as temperature is higher. Replace TMAP sensor if determined to be faulty.
   b. If it is within specifications, proceed to Step 6.
6. Check circuits (input, ground), from main harness connector to sensor plug for continuity, damage, etc. Connect one ohmmeter lead to Black pin 8 in main harness connector (as in step 4). Connect other lead to terminal #3 in sensor plug. Continuity should be indicated. Repeat test between Black pin 10 and terminal #4 in sensor plug.
7. Reinstall sensor.

If a blink code indicates a problem with Manifold Absolute Pressure (TMAP) Sensor Circuit (P0107 or P0108), it can be tested as follows:

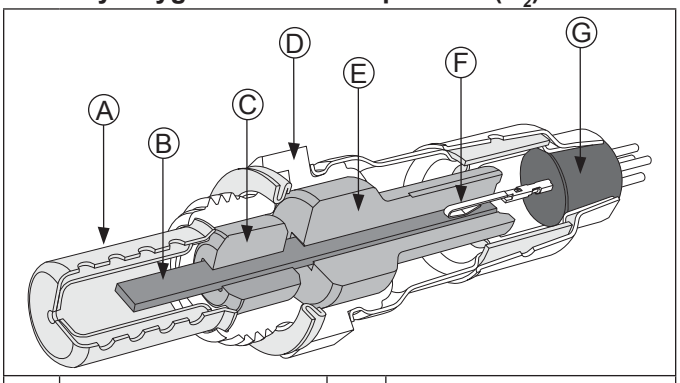
1. Make sure all connections are making proper contact and are free of dirt and debris. Slide locking tab out and pull off TMAP connector. Turn key switch to ON and check with a volt meter by contacting red lead to pin 1 and black lead to pin 2. There should be 5 volts present, indicating ECU and wiring harness are functioning.
2. Check continuity in wire harness. Ohms between Pin 3 at sensor connector and Black pin 11 connector at ECU should be near zero ohms. If no continuity is measured or very high resistance, replace wire harness.
3. Check to make sure intake manifold is not loose and TMAP sensor is not loose. Loose parts would allow a vacuum leak, making TMAP sensor report misleading information to ECU.
   a. Tighten all hardware and perform an ECU Reset and a TPS Learn Procedure to see if MIL will display a fault with sensor again. If MIL finds a fault with TMAP sensor, replace it.

Oxygen Sensor (O_2)

Components



Cutaway Oxygen Sensor Components (O_2)



A	Protection Shield	**B**	Planar Element and Heater
C	Lower Insulator	**D**	Stainless Steel Housing
E	Upper Insulator	**F**	Terminal Connection to Element
G	High Temp Water Seal		

Temperature must be controlled very accurately and gas constituents measured to a high degree of accuracy for absolute sensor measurements. This requires laboratory equipment to determine a good or bad sensor in field. Furthermore, as with most devices, intermittent problems are difficult to diagnose. Still, with a good understanding of system and sensor, it is possible to diagnose many sensor problems in field.

Using diagnostic software connected to ECU is a useful technique for observing sensor performance. However, user must understand that such software reads a signal generated by ECU. If there is an ECU or wiring problem, readings could be misinterpreted as a sensor problem. Digital nature of signal to software means that it is not reading continuous output of sensor. A voltmeter can also be used as an effective tool in diagnosing sensors. It is advisable to use an electronic meter such as a digital voltmeter. Simple mechanical meters may place a heavy electrical load on sensor and cause inaccurate readings. Since resistance of sensor is highest at low temperatures, such meters will cause largest inaccuracies when sensor is in a cool exhaust.

Visual Inspection

1. Look for a damaged or disconnected sensor-to-engine harness connection.
2. Look for damage to sensor lead wire or associated engine wiring due to cutting, chaffing or melting on a hot surface.
3. Disconnect sensor connector and look for corrosion in connector.
4. Try reconnecting sensor and observe if problem has cleared.
5. Correct any problems found during visual check.

Sensor Signal Observation

NOTE: **Do not cut into or pierce sensor or engine wiring to make this connection.** Sensor produces a very small signal. Corrosion or damage to wiring could lead to an incorrect signal because of repairs or contamination to sensor.

1. Using a voltmeter or diagnostic software observe voltage before engine is started. With key ON, voltage should read about 1.0 volt. This voltage is generated by ECU. If it is not present, disconnect sensor and observe voltage at harness connector. If voltage is now present, there is a short in sensor or associated wiring and corrective action should be taken. If voltage still is not present, there is a problem with ECU or engine harness.
2. Reconnect sensor and start engine. Run engine at sufficient speed to bring sensor up to operating temperature. Maintain for 1 to 2 minutes to ensure that engine has gone closed loop. Once in closed loop, sensor voltage should cycle between about 100 to 250 mv and 700 to 900 mv. If this cycling is not observed, a determination must be made, if problem is with engine or sensor.
3. Check engine harness for battery voltage on heater circuit.

Removal Inspection

NOTE: Apply anti-seize compound only to threads. **Anti-seize compound will affect sensor performance if it gets into lower shield of sensor.**

1. If sensor has heavy deposits on lower shield, engine, oil, or fuel may be source.
2. If heavy carbon deposits are observed, incorrect engine fuel control may be occurring.
3. If sensor is at room temperature, measure between signal leads, black wire (Pin C) and grey wire (Pin D) attached to sensor. If resistance is less than one megohm, sensor has an internal short.
4. With sensor at room temperature measure heater circuit resistance, purple wire (Pin A) and white wire (Pin B), resistance should be 8.1-11.1 Ω.
5. If a damaged sensor is found, identify root cause, which may be elsewhere in application. Refer to Troubleshooting-Oxygen Sensor (O_2) table.
6. A special "dry to touch" anti-seize compound is applied to all new oxygen sensors at factory. If recommended mounting thread sizes are used, this material provides excellent anti-seize capabilities and no additional anti-seize is needed. If sensor is removed from engine and reinstalled, anti-seize compound should be reapplied. Use an oxygen sensor safe type anti-seize compound. It should be applied according to directions on label.

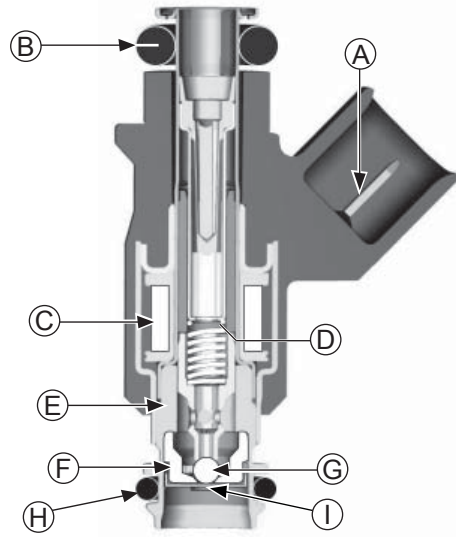
Troublshooting-Oxygen Sensor (O_2)

Condition	Possible Cause	Conclusion
Low voltage output.	Shorted sensor or sensor circuit. Shorted lead wire. Wiring shorted to ground.	Replace sensor or repair wiring.
	Contamination of air reference.	Remove source of external contamination, protect air reference area.
	Air leak at sensor or gasket, sensor upper shield damage.	Use recommended torque at installation, replace gasket or sensor. Revise application exhaust. Shield sensor from damage.
High voltage output.	Silica poisoning.	Replace sensor.
	Contaminated gasoline.	Use high quality fuel.
	Engine problem; misfire.	Correct cause of misfire.
	Excessive rich air/fuel ratio.	Check for high fuel pressure Leaking injector Liquid fuel in vent line
	Wiring shorted to voltage.	Repair wiring.
Open circuit, no activity from sensor.	Broken element. Sensor dropped. Hard blow to engine or exhaust system. Defective sensor. Thermal shock.	Replace sensor.
Slow time response.	Open heater circuit. Improper handling. Carbon deposits.	Replace sensor.
	Improper fueling.	Correct fueling.
	Incorrect or contaminated fuel.	Use high quality fuel.
	Excessive engine oil consumption causing exhaust contamination or other exhaust side contamination.	Correct engine condition.
	Heater circuit open/shorted or out of specification.	Repair short in harness wires, replace sensor.

Fuel Injectors

	⚠ WARNING
	Explosive Fuel can cause fires and severe burns. Fuel system ALWAYS remains under HIGH PRESSURE.
Wrap a shop towel completely around fuel pump module connector. Press release button(s) and slowly pull connector away from fuel pump module allowing shop towel to absorb any residual fuel in high pressure fuel line. Any spilled fuel must be completely wiped up immediately.	

Details



A	Electrical Connection	**B**	Upper O-ring
C	Solenoid Winding	**D**	Armature
E	Valve Housing	**F**	Valve Seat
G	Valve End	**H**	Lower O-ring
I	Director Plate		

NOTE: Do not apply voltage to fuel injector(s). Excessive voltage will burn out injector(s). Do not ground injector(s) with ignition ON. Injector(s) will open/turn on if relay is energized.

NOTE: When cranking engine with injectors disconnected, fault codes will be registered in ECU and will need to be cleared using software fault clear or an ECU Reset and TPS Learn Procedure.

Injector problems typically fall into three general categories: electrical, dirty/clogged, or leakage. An electrical problem usually causes one or both of injectors to stop functioning. Several methods may be used to check if injectors are operating.

1. With engine running at idle, listen for a buzzing or clicking sound.
2. Disconnect electrical connector from an injector and listen for a change in idle performance (only running on one cylinder) or a change in injector noise or vibration.

If an injector is not operating, it can indicate either a bad injector, or a wiring/electrical connection problem. Check as follows:

1. Disconnect electrical connector from both injectors. Plug a 12 volt noid light into one connector.
2. Make sure all safety switch requirements are met. Crank engine and check for flashing of test light. Turn key OFF for at least 10 seconds between tests to allow ECU to go to sleep and reawake. Repeat test at other connector.
   a. If flashing occurs, use an ohmmeter (Rx1 scale) and check resistance of each injector across two terminals. Proper resistance is 11-13 Ω. If injector resistance is correct, check whether connector and injector terminals are making a good connection. If resistance is not correct, replace injector.

Check all electrical connections, connectors, and wiring harness leads if resistance is incorrect.

Injector leakage is very unlikely, but in those rare instances it can be internal (past tip of valve needle), or external (weeping around injector O-rings). Loss of system pressure from leakage can cause hot restart problems and longer cranking times. Refer to Disassembly for removal of injector.

1. Remove manifold mounting bolts and separate throttle body/manifold from engine leaving TPS, high pressure fuel line, injectors and fuel line connections intact. Discard old gaskets.
2. Position manifold assembly over an appropriate container to capture fuel and turn key switch ON to activate fuel pump and pressurize system. Do not turn switch to START position.

NOTE: Fuel pump module pins are coated with a thin layer of electrical grease to prevent fretting and corrosion. Do not attempt to remove electrical grease from fuel pump module pins.

3. If either injector exhibits leakage of more than two to four drops per minute from tip, or shows any sign of leakage around outer shell, turn ignition switch OFF and replace injector as follows.
4. Depressurize fuel system.
5. Clean any dirt accumulation from sealing/mounting area of faulty injector(s) and disconnect electrical connector(s).
6. Pull retaining clip off top of injector(s). Remove screw holding injector(s) from manifold.
7. Reverse appropriate procedures to install new injector(s) and reassemble engine. Use new O-rings and retaining clips any time an injector is removed (new replacement injectors include new O-rings and retaining clips). Lubricate O-rings lightly with clean engine oil. Use installation tool provided with O-rings to install new upper O-ring. Place tool into fuel injector inlet. Place one side of O-ring into O-ring groove and roll O-ring over tool onto fuel injector. Torque screw securing fuel injector caps to 7.3 N·m (65 in. lb.). An ECU Reset and TPS Learn Procedure will need to be completed.

Injector problems due to dirt or clogging are generally unlikely due to design of injectors, high fuel pressure, and detergent additives in gasoline. Symptoms that could be caused by dirty/clogged injectors include rough idle, hesitation/stumbling during acceleration, or triggering of fault codes related to fuel delivery. Injector clogging is usually caused by a buildup of deposits on director plate, restricting flow of fuel, resulting in a poor spray pattern. Some contributing factors to injector clogging include higher than normal operating temperatures, short operating intervals, and dirty, incorrect, or poor quality fuel. Cleaning of clogged injectors is not recommended; they should be replaced. Additives and higher grades of fuel can be used as a preventative measure if clogging has been a problem.

Ignition Coils

This engine is equipped with dual-plug coils. Either they both fire or neither will fire. If a coil is determined to be faulty, replacement is necessary. An ohmmeter may be used to test wiring and coil windings.

NOTE: Do not ground primary coil with ignition ON as they may overheat or spark.

NOTE: Always disconnect both spark plug leads from spark plugs before performing following tests.

NOTE: **If ignition coil(s) are disabled and an ignition fault is registered, system will automatically disable corresponding fuel injector drive signal.** Fault must be corrected to ignition coil and ECU power (switch) must be turned OFF for 10 seconds for injector signal to return. This is a safety measure to prevent bore washing and oil dilution.

Testing

Using an ohmmeter set on Rx1 scale, check resistance in circuits as follows:

1. To check cylinder coil 1 (starter side), disconnect Black connector from ECU and test between Black pins 1 and 15. To check cylinder coil 2 (oil filter side), disconnect Grey connector from ECU and test between Grey pins 10 and 17. Wiring and coil primary circuits are OK if readings are 0.85-1.15 Ω.
2. If reading(s) are not within specified range, check and clean connections and retest.
3. If reading(s) are still not within specified range, test coils separately from main harness as follows:
   a. Remove mounting screws retaining coil and disconnect primary leads connector.
   b. Connect an ohmmeter set on Rx1 scale to primary terminals of coil. Primary resistance should be 0.85-1.15 Ω.
   c. Connect ohmmeter leads (set on Rx200K scale) between both spark plug boot terminals. Secondary resistance should be 15000-25000 Ω.
   d. If either primary or secondary resistance is not within specified range, coil is faulty and needs to be replaced.

FUEL COMPONENTS

	⚠ WARNING
	Explosive Fuel can cause fires and severe burns. Fuel system ALWAYS remains under HIGH PRESSURE.
Wrap a shop towel completely around fuel pump module connector. Press release button(s) and slowly pull connector away from fuel pump module allowing shop towel to absorb any residual fuel in high pressure fuel line. Any spilled fuel must be completely wiped up immediately.	

Fuel Pump Module (FPM)

FPM is not serviceable and must be replaced if determined to be faulty. If a FPM problem is suspected, make certain pump is being activated, all electrical connections are properly secured and fuses are good. If required, testing of FPM may be conducted.

1. Relieve fuel pressure at FPM. FPM may need to be loosened or pulled away from engine. Press release button(s) and slowly pull connector away from FPM allowing shop towel to absorb any residual fuel in high pressure fuel line. Insert pressure test jumper (from Kohler EFI Service Kit) between high pressure fuel line and FPM.
2. Connect black hose of Pressure Tester. Route clear hose into a portable gasoline container or equipment fuel tank.
3. Turn on key switch to activate pump and check system pressure on gauge. It may take several key cycles to compress air introduced into system and reach regulated pressure. System pressure of 39 psi ± 3 should be present. Turn key switch OFF and depress valve button on tester to relieve system pressure.
   a. If pressure is too high or too low, proceed to troubleshooting.
4. If pump did not activate (step 3), confirm that safety system on equipment is not active. One potential cause of unnecessary FPM replacement may involve measuring voltage at FPM electrical connector. Using a Digital Volt Ohm Meter (DVOM) will provide a reading near battery voltage, even when ECU is not grounding FPM circuit.
   a. Connect a DVOM across terminals in plug, turn on key switch and confirm battery voltage is present during six second prime process.
   b. Test light confirmation: Turn key off. Disconnect DVOM. Connect 12 volt test light across terminals in plug. Key needs to remain off for a minimum of 30 seconds before proceeding. Turn key on. Confirm test light illuminates for approximately 6 seconds. After approximately 6 seconds, test light will remain off unless another prime cycle is initiated.

5. If battery voltage is not present and/or test light does not illuminate, connect red lead of DVOM to red wire of plug and black lead to a battery ground while key is still ON.
6. If battery voltage is present, turn key switch OFF and connect an ohmmeter between terminals on FPM to check for continuity. If battery voltage at plug was confirmed, and there was continuity across FPM terminals, reconnect plug to FPM, making sure you have a good connection. Turn on key switch and listen for FPM to activate.
   a. If FPM starts, repeat steps 2 and 3 to verify correct pressure.
   b. If FPM still does not operate, replace it.
7. If battery voltage was not present at connector inspect fuse and wiring harness.

High Pressure Fuel Line

High pressure fuel line is mounted to bracket on intake manifold. No specific servicing is required unless operating conditions indicate that it needs replacement. Thoroughly clean area around all joints and relieve any pressure before starting any disassembly. Detach by removing two mounting screws, wire ties, and injector retaining clips.

Purge Port and Vent Hose Assembly

No specific servicing is required for vent hose assembly or purge port unless operating conditions indicate replacement is required. All components are serviced individually. Abrasion sleeves on hoses should be reused or replaced when servicing vent hoses. Please note vent hose routing and replicate after service or component replacement to prevent pinching or abrasion of vent hoses. Only Kohler replacement parts can be used because fitting is specific to system and must be maintained. Visit KohlerEngines.com for recommended Kohler replacement parts.

Throttle Body/Intake Manifold Assembly

NOTE: ECU Reset is required if throttle body is replaced.

Throttle body is serviced as an assembly, with throttle shaft, TPS, throttle plate, and idle speed adjusting screw installed. Throttle shaft rotates on needle bearings (non-serviceable), capped with seals to prevent air leaks.

TROUBLESHOOTING

Troubleshooting Guide

Condition	Possible Cause
Engine Starts Hard or Fails to Start When Cold.	Fuel pump not running.
	Faulty spark plugs.
	Old/stale fuel.
	Incorrect fuel pressure.
	Crankshaft position sensor loose or faulty.
	TPS set incorrect (ECU Reset and TPS Learn).
	TPS faulty.
	Engine temp sensor faulty.
	Faulty coils.
	Low system voltage.
	Faulty injectors.
	Faulty battery.
	Loose or corroded connections.
Engine Starts Hard or Fails to Start When Hot.	Faulty spark plugs.
	Fuel pump not running.
	Fuel pressure low.
	Insufficient fuel delivery.
	TPS set incorrect (ECU Reset and TPS Initialization).
	Crankshaft position sensor loose or faulty.
	TPS faulty.
	Engine temp sensor faulty.
	Faulty injectors.

Troubleshooting Guide

Condition	Possible Cause
Engine Stalls or Idles Roughly (cold or warm).	Faulty spark plugs.
	Insufficient fuel delivery.
	TPS set incorrect.
	TPS faulty.
	Faulty engine temperature sensor.
	Faulty injectors.
Engine Misses, Hesitates, or Stalls Under Load.	Fuel injector(s), fuel filter, fuel line, or fuel pick-up dirty/restricted.
	Dirty air cleaner.
	Insufficient fuel pressure or fuel delivery.
	Vacuum (intake air) leak.
	Improper governor setting, adjustment or operation.
	TPS faulty, mounting problem or TPS Initialization Procedure incorrect.
	Bad coil(s), spark plug(s), or wires.
Low Power	Faulty/malfunctioning ignition system.
	Dirty air filter.
	Insufficient fuel delivery.
	Improper governor adjustment.
	Plugged/restricted exhaust.
	One injector not working.
	Basic engine problem exists.
	TPS faulty or mounting exists.
	Throttle plate in throttle body not fully opening to WOT stop (if equipped).

Function Test

⚠ WARNING

High Pressure Fluids can puncture skin and cause severe injury or death.

Do not work on fuel system without proper training or safety equipment.

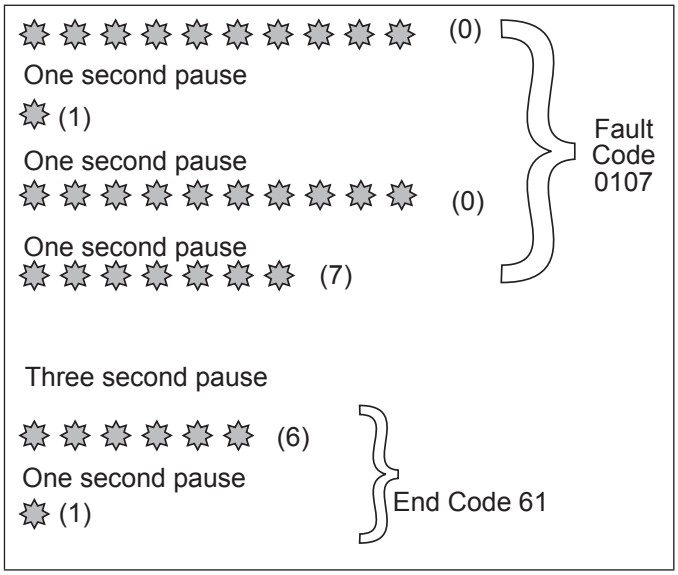
Fluid puncture injuries are highly toxic and hazardous. If an injury occurs, seek immediate medical attention.

Function of fuel system is to provide sufficient delivery of fuel at system operating pressure of 39 psi ± 3. If an engine starts hard, or turns over but will not start, it may indicate a problem with EFI fuel system. A quick test will verify if system is operating.

1. Disconnect and ground spark plug leads.
2. Complete all safety interlock requirements and crank engine for approximately 3 seconds.
3. Remove spark plugs and check for fuel at tips.
   a. If there is fuel at tips of spark plugs fuel pump and injectors are operating.
   b. If there is no fuel at tips of spark plugs, check following:
      1. Make sure fuel tank contains clean, fresh, proper fuel.
      2. Make sure that vent in fuel tank is open.
      3. Make sure fuel tank valve (if equipped) is fully opened.
      4. Make sure battery is supplying proper voltage.
      5. Check that fuses are good, and that no electrical or fuel line connections are damaged or broken.
      6. Test fuel pump module operation as described earlier under Fuel Pump Module (FPM).

Fault Codes

Example of Diagnostic Display



Diagnostic Fault Code Summary

Fault Code	Connection or Failure Description
0031	Oxygen Sensor Heater Circuit Low Voltage
0032	Oxygen Sensor Heater Circuit High Voltage
0107	Manifold Absolute Pressure (TMAP) Circuit Low Voltage or Open
0108	Manifold Absolute Pressure (TMAP) Circuit High Voltage
0112	Intake Air Temperature (TMAP) Circuit Low Voltage
0113	Intake Air Temperature (TMAP) Circuit High Voltage or Open
0117	Coolant/Oil Temperature Sensor Circuit Low Voltage
0118	Coolant/Oil Temperature Sensor Circuit High Voltage or Open
0122	Throttle Position Sensor Circuit Low Voltage or Open
0123	Throttle Position Sensor Circuit High Voltage
0131	Oxygen Sensor 1 Circuit Low Voltage, or Open
0132	Oxygen Sensor 1 Circuit High Voltage
0171	Maximum Adaptation Limit Exceeded
0172	Minimum Adaptation Limit Exceeded
0174	Lean Fuel Condition at High Load (Open Loop)
0201	Injector 1 Circuit Malfunction
0202	Injector 2 Circuit Malfunction

0230	Fuel Pump Module Circuit Low Voltage or Open
0232	Fuel Pump Module Circuit High Voltage
0336	Crankshaft Position Sensor Noisy Signal
0337	Crankshaft Position Sensor No Signal
0351	Cylinder 1 Ignition Coil Malfunction
0352	Cylinder 2 Ignition Coil Malfunction
0562	System Voltage Low
0563	System Voltage High
1693	Tach Output (ECU) Low
1694	Tach Output (ECU) High
61	End of Code Transmission

ECU continuously monitors engine operation against preset performance limits. If operation is outside limits, ECU activates MIL, if equipped, and stores a diagnostic code in its fault memory. If component or system returns to proper function, ECU will turn off MIL. If MIL stays illuminated, it warns customer a fault is currently happening, and dealer service is required. Upon receipt, dealer technician can access fault code(s) to help determine what portion of system is malfunctioning.

Codes are accessed through key switch and displayed as blinks or flashes of MIL. Access codes as follows:

1. Check that battery voltage is above 11 volts.
2. Start with key switch OFF.
3. Turn key switch to ON and OFF, then ON and OFF, then ON, leaving it on in third sequence. Do not start engine. Time between sequences must be less than 2.5 seconds.
4. MIL will blink a series of times. Number of times MIL blinks represents a number in blink code.
5. A sequence of four digits make up a fault code. There is a one (1) second pause between blinks of a fault code. There is a three (3) second pause between separate fault codes. After fault code(s) are blinked a two digit 61 is blinked to indicate program has completed.
   a. It's a good idea to write down codes as they appear, as they may not be in numerical sequence.
   b. Code 61 will always be last code displayed, indicating end of code transmission. If code 61 appears immediately, no other fault codes are present.

After problem has been corrected, fault codes may be cleared by following ECU Reset and TPS Learn Procedures.

Diagnostic Fault Code Summary lists fault codes, and what they correspond to. Diagnostic Code Summary is a list of individual codes with an explanation of what triggers them, what symptoms might be expected, and probable causes.

A MIL may not be provided with engine. If equipment manufacturer has not added a MIL to equipment, one can be added easily for quick diagnostics. Main engine to vehicle connection will have a tan wire which is ground for MIL. Either incandescent or LED type bulbs can be used for MIL as long as they do not draw more than 0.1 amps. Bulb needs to be rated at 1.4 Watts or less, or needs to have a total resistance of 140 Ω or more. LEDs typically draw less than 0.03 amps. Attach +12 volts to positive terminal of bulb and attach ground terminal of bulb to tan wire.

Diagnostic Code Summary

Code 0031

Component:	Oxygen Sensor Heater
Fault:	O2S Heater Circuit Low Voltage
Condition:	System voltage too low, open connection or faulty sensor.
Conclusion:	Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU black pin 7 or broken wire. Oxygen Sensor Related ● Sensor connector or wiring problem. Poor system ground from ECU to engine or battery to engine.

Code 0032

Component:	Oxygen Sensor Heater
Fault:	O2S Heater Circuit High Voltage
Condition:	System voltage too high, shorted connection or faulty sensor.
Conclusion:	Oxygen Sensor Related ● Sensor connector or wiring problem. ● Sensor damaged. ● Pin circuit wiring or connectors at Black 7. ECU Related ● ECU-to-harness connection problem.

Code 0107

Component:	Manifold Absolute Pressure (TMAP)
Fault:	MAP Circuit Low Voltage or Open
Condition:	Intake manifold leak, open connection or faulty sensor.
Conclusion:	TMAP Sensor Related ● Sensor malfunction. ● Vacuum leaks from loose manifold or sensor. Wire Harness Related ● Poor grounding or open circuit. ● Wire harness and connectors loose, damaged or corroded. ● Pin circuit wiring or connectors at Black 10, 11 and 16. Bad TPS Learn.

Code 0108

Component:	Manifold Absolute Pressure (TMAP)
Fault:	MAP Circuit High Voltage
Condition:	Intake manifold leak, shorted connection or faulty sensor.
Conclusion:	TMAP Sensor Related ● Sensor malfunction. ● Vacuum leaks from loose manifold or sensor. Wire Harness Related ● Poor grounding. ● Pin circuit wiring or connectors at Black 11. Bad TPS Learn.

Code 0112

Component:	Intake Air Temperature (TMAP)
Fault:	Intake Air Temperature Sensor Circuit Low Voltage
Condition:	Shorted connection, faulty sensor or shorted wire.
Conclusion:	TMAP Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits Black 10 and Black 8 may be damaged or routed near noisy signal (coils, alternator, etc.). ● ECU-to-harness connection problem.

Code 0113

Component:	Intake Air Temperature (TMAP)
Fault:	Intake Air Temperature Sensor Circuit High Voltage or Open
Condition:	Shorted connection, faulty sensor, broken wire or connection.
Conclusion:	TMAP Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits ECU Black pin 10 and 8 may be damaged. ● ECU-to-harness connection problem or broken wire.

Code 0117

Component:	Coolant/Oil Sensor
Fault:	Coolant/Oil Temperature Sensor Circuit Low Voltage
Condition:	Shorted connection, faulty sensor or shorted wire.
Conclusion:	Temperature Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits Black 10 and Black 14 maybe damaged or routed near noisy signal (coils, stator, etc.). ● ECU-to-harness connection problem.

Code 0118

Component:	Coolant/Oil Sensor
Fault:	Coolant/Oil Temperature Sensor Circuit High Voltage or Open
Condition:	Shorted connection, faulty sensor, open connection or broken wire.
Conclusion:	Temperature Sensor Related ● Sensor wiring or connection. Engine Wiring Harness Related ● Pin circuits ECU Black pin 10 and 14 may be damaged. ● ECU-to-harness connection problem or broken wire. System Related ● Engine is operating above 176°C (350°F) temperature sensor limit.

Code 0122

Component:	Throttle Position Sensor (TPS)
Fault:	TPS Circuit Low Voltage or Open
Condition:	Open connection, broken wire or faulty sensor.
Conclusion:	TPS Related ● TPS bad or worn internally. Engine Wiring Harness Related ● Broken or shorted wire in harness. ECU Black pin 10 to TPS pin 1. ECU Black pin 12 to TPS pin 3. ECU Black pin 16 to TPS pin 2. Throttle Body Related ● Throttle shaft inside TPS worn, broken, or damaged. ● Throttle plate loose or misaligned. ● Throttle plate bent or damaged allowing extra airflow past, or restricting movement. ECU Related ● Circuit providing voltage or ground to TPS damaged. ● TPS signal input circuit damaged.

Code 0123

Component:	Throttle Position Sensor (TPS)
Fault:	TPS Circuit High Voltage
Condition:	Shorted connection or faulty sensor.
Conclusion:	TPS Sensor Related ● Sensor connector or wiring. ● Sensor output affected or disrupted by dirt, grease, oil, wear. ● Sensor loose on throttle body manifold. Throttle Body Related ● Throttle shaft or bearings worn/ damaged. Engine Wiring Harness Related ● ECU pins Black 10, 12 and 16 damaged (wiring, connectors). ● ECU pins Black 10, 12 and 16 routed near noisy electrical signal (coils, alternator). ● Intermittent 5 volt source from ECU (pin Black 16). ● ECU-to-harness connection problem.

Code 0131

Component:	Oxygen Sensor
Fault:	O2S 1 Circuit Low Voltage
Condition:	Open connection, broken wire or faulty sensor.
Conclusion:	Oxygen Sensor Related ● Sensor connector or wiring problem. ● Sensor contaminated, corroded or damaged. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or 17. TPS Learn Procedure Incorrect ● Lean condition (check oxygen sensor signal with VOA and see Oxygen Sensor section). Engine wiring harness related such as a cut wire, broken or pinched.

Code 0132

Component:	Oxygen Sensor
Fault:	O2S 1 Circuit High Voltage
Condition:	Shorted connection or faulty sensor.
Conclusion:	Oxygen Sensor Related ● Sensor connector or wiring problem. ● Sensor contaminated or damaged. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or Black pin 17. Engine Wiring Harness Related ● Difference in voltage between sensed voltage and actual sensor voltage. ● Short in wire harness.

Code 0171

Component:	Fuel System
Fault:	Maximum adaptation limit exceeded
Condition:	Fuel inlet screen/filter plugged, low pressure at high pressure fuel line, TPS malfunction, shorted connection, faulty sensor, low fuel or wrong fuel type.
Conclusion:	Oxygen Sensor Related ● Corrosion or poor connection. ● Sensor contaminated or damaged. ● Air leak into exhaust. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or Black pin 17. TPS Sensor Related ● Throttle plate position incorrect during Learn procedure. ● TPS problem or malfunction. Engine Wiring Harness Related ● Difference in voltage between sensed voltage and actual sensor voltage. ● Problem in wiring harness. ● ECU-to-harness connection problem. Systems Related ● Ignition (spark plug, plug wire, ignition coil). ● Fuel (fuel type/quality, injector, fuel pressure too low, fuel pump module or lift pump). ● Combustion air (air cleaner dirty/ restricted, intake leak, throttle bores). ● Base engine problem (rings, valves). ● Exhaust system leak (muffler, flange, oxygen sensor mounting boss, etc.). ● Fuel in crankcase oil.

Code 0172

Component:	Fuel System
Fault:	Minimum adaptation limit exceeded
Condition:	Too high pressure at high pressure fuel line, TPS malfunction, shorted connection, faulty sensor or fuel pump module failure.
Conclusion:	Oxygen Sensor Related ● Sensor connector or wiring. ● Sensor contaminated or damaged. ● Poor ground path. ● Pin circuit wiring or connectors. ECU Black pin 10 or 17. TPS Sensor Related ● Throttle plate position incorrect during Learn procedure. ● TPS problem or malfunction. Engine Wiring Harness Related ● Difference in voltage between sensed voltage and actual sensor voltage. ● Problem in wiring harness. ● ECU-to-harness connection problem. Systems Related ● Ignition (spark plug, plug wire, ignition coil). ● Fuel (fuel type/quality, injector, fuel pressure too high, fuel pump module or lift pump). ● Combustion air (air cleaner dirty/ restricted). ● Base engine problem (rings, valves). ● Fuel in crankcase oil. ● Fuel pump module is over filled. ● Lift pump diaphragm is ruptured.

Code 0174

Component:	Fuel System
Fault:	Lean fuel condition
Condition:	Fuel inlet screen/filter plugged, low pressure at high pressure fuel line, TPS malfunction, shorted connection or faulty sensor.
Conclusion:	TPS Learn Incorrect ● Lean condition (check oxygen sensor signal with VOA and see Oxygen Sensor). Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU pin Black 10, 12, 16 and 17. Low Fuel Pressure ● Plugged filters. ● Bad lift pump. Oxygen Sensor Related ● Sensor connector or wiring problem. ● Exhaust leak. ● Poor ground. Poor system ground from ECU to engine, causing rich running while indicating lean. Fuel pump module connection. See Fuel Components.

Code 0201

Component:	Fuel Injector
Fault:	Injector 1 Circuit Malfunction
Condition:	Injector damaged or faulty, shorted or open connection.
Conclusion:	Injector Related ● Injector coil shorted or opened. Engine Wiring Harness Related ● Broken or shorted wire in harness. ECU pin Black 5. ● Wiring from Ignition. ECU Related ● Circuit controlling injector #1 damaged.

Code 0202

Component:	Fuel Injector
Fault:	Injector 2 Circuit Malfunction
Condition:	Injector damaged or faulty, shorted or open connection.
Conclusion:	Injector Related ● Injector coil shorted or opened. Engine Wiring Harness Related ● Broken or shorted wire in harness. ECU pin Black 6. ● Wiring from Ignition. ECU Related ● Circuit controlling injector #2 damaged.

Code 0230

Component:	Fuel Pump
Fault:	Circuit Low Voltage or Open
Condition:	Shorted or open connection.
Conclusion:	Fuel Pump Related ● Fuel pump module open or shorted internally. Engine Wiring Harness related ● Broken or shorted wire in harness. ECU pin Black 9 or Grey 17. ECU Related ● ECU is damaged.

Code 0232

Component:	Fuel Pump
Fault:	Circuit High Voltage
Condition:	Shorted connection.
Conclusion:	Fuel Pump Related ● Fuel pump module damaged internally. Charging Output System Too High.

Code 0336

Component:	Crankshaft Position Sensor
Fault:	Crankshaft Position Sensor Noisy Signal
Condition:	Loose sensor, faulty/bad battery, shorted or faulty connection, faulty sensor or faulty sensor grounding.
Conclusion:	Crankshaft Position Sensor Related ● Sensor connector or wiring. ● Sensor loose. Crankshaft Position Sensor Wheel Related ● Damaged teeth. ● Gap section not registering. Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU pin Black 4 and Black 13. ● ECU-to-harness connection problem. Ignition System Related ● Non-resistor spark plug(s) used. ● Faulty or disconnected ignition coil or secondary lead.

Code 0337

Component:	Crankshaft Position Sensor
Fault:	Crankshaft Position Sensor No Signal
Condition:	Loose sensor, open or shorted connection or faulty sensor.
Conclusion:	Crankshaft Position Sensor Related ● Sensor connector or wiring. ● Sensor loose. Crankshaft Position Sensor Wheel Related ● Damaged teeth. Engine Wiring Harness Related ● Pin circuit wiring or connectors. ECU pin Black 4 or Black 13. ● ECU-to-harness connection problem. If code is stored in fault history and starts normally. Clear code, no other service required.

Code 0351

Component:	Ignition Coil
Fault:	Cylinder 1 Ignition Coil Malfunction
Condition:	Broken wire in harness (may not be visible), shorted connection or faulty sensor.
Conclusion:	Engine Wiring Harness Related ● Connection to ignition or fuse. ● Pin circuit wiring or connectors. ● ECU pin Black 1. ● ECU-to-harness connection problem. Ignition System Related ● Incorrect spark plug(s) used. ● Poor connection to spark plug.

Code 0352

Component:	Ignition Coil
Fault:	Cylinder 2 Ignition Coil Malfunction
Condition:	Broken wire in harness (may not be visible), shorted connection or faulty sensor.
Conclusion:	Engine Wiring Harness Related ● Connection to ignition or fuse. ● Pin circuit wiring or connectors. ECU pin Grey 10. ● ECU-to-harness connection problem. Ignition System Related ● Incorrect spark plug(s) used. ● Poor connection to spark plug.

Code 0562

Component:	System Voltage
Fault:	System Voltage Low
Condition:	Faulty voltage regulator, bad fuse or shorted connection.
Conclusion:	Corroded Connections Bad Stator Bad Battery ● Low output charging system. ● Poor magnet in flywheel. ● Bad or missing fuse.

Code 0563

Component:	System Voltage
Fault:	System Voltage High
Condition:	Faulty voltage regulator or shorted connection.
Conclusion:	Faulty Rectifier-Regulator Bad Stator. Bad Battery.

Code 1693

Component:	Tach Output (ECU)
Fault:	Tach Circuit Low
Condition:	Tachometer output circuit short to ground.
Conclusion:	Bad Tach Wire (grounded). GCU circuit short to ground.

Code 1694

Component:	Tach Output (ECU)
Fault:	Tach Circuit High
Condition:	Tachometer output circuit short to battery.
Conclusion:	ECU or GCU circuit error.

Code 61

Component:	End of Code Transmission

Troubleshooting Flow Chart

Following a flow chart provides an alternative method of troubleshooting EFI system. Chart will enable you to review entire system in about 10-15 minutes. Using chart, accompanying diagnostic aids (listed chart), and any signaled fault codes, you should be able to quickly locate any problems within system.

Flow Chart Diagnostic Aids

Diagnostic Aid #1 SYSTEM POWER

(MIL does not illuminate when key is turned ON)

NOTE: MIL is installed by vehicle OEM. Twelve volt supply to bulb will be part of vehicle wire harness. Kohler key switch model will have MIL on engine with 12V supply to bulb.

Conclusion

- Battery
- Main system fuse
- MIL light bulb burned out
- MIL electrical circuit problem
  Pin circuits Grey 3.
- Ignition switch
- Permanent ECU power circuit problem
  Pin circuit Black 18.
- Switched ECU power circuit problem
  Pin circuit Black 15.
- ECU grounds
- ECU

Diagnostic Aid #2 FAULT CODES

Refer to Diagnostic Fault Code Summary.

Diagnostic Aid #3 RUN/ON

(MIL remains ON while engine is running)*

Condition

NOTE: Either incandescent or LED type bulbs can be used for MIL as long as they do not draw more than 0.1 amps. Bulb needs to be rated at 1.4 Watts or less, or needs to have a total resistance of 140 Ω or more. LEDs typically draw less than 0.03 amps.

*All current fault codes will turn on MIL when engine is running.

Diagnostic Aid #4 CRANKSHAFT POSITION SENSOR

(MIL does not turn off during cranking)

Condition

- Crankshaft position sensor
- Crankshaft position sensor circuit problem, pin circuits Black 4 and Black 13.
- Crankshaft position sensor/toothed wheel air gap
- Toothed wheel
- Flywheel key sheared
- ECU

Diagnostic Aid #5 FUEL PUMP

(fuel pump not turning on)

Condition

- Inspect fuse(s)
- Fuel pump circuit problem, pin circuits Black 9 and Grey 17.
- Fuel pump module

Diagnostic Aid #6 IGNITION SYSTEM

(no spark)

Condition

- Spark plug
- Plug wire
- Coil
- Coil circuit(s), pin circuits Grey 10 and Black 1.
- ECU grounds
- ECU
- Vehicle safety interlocks, ground signal on safety wire.

Diagnostic Aid #7 FUEL SYSTEM ELECTRICAL

(no fuel delivery)

Condition

- No fuel
- Air in high pressure fuel line
- Fuel valve shut OFF
- Fuel filter/line plugged
- Injector circuit(s), pin circuits Black 5 and Black 6
- Injector
- ECU grounds
- ECU
- Lift pump not working

Diagnostic Aid #8 FUEL SYSTEM

(fuel pressure)

Low Fuel Pressure-Condition

- No fuel
- Fuel filter(s) plugged
- Fuel supply line plugged
- Lift fuel pump - insufficient fuel supply
- Fuel pump (lift or module) - internally plugged
- Pressure regulator not functioning properly inside fuel pump module.

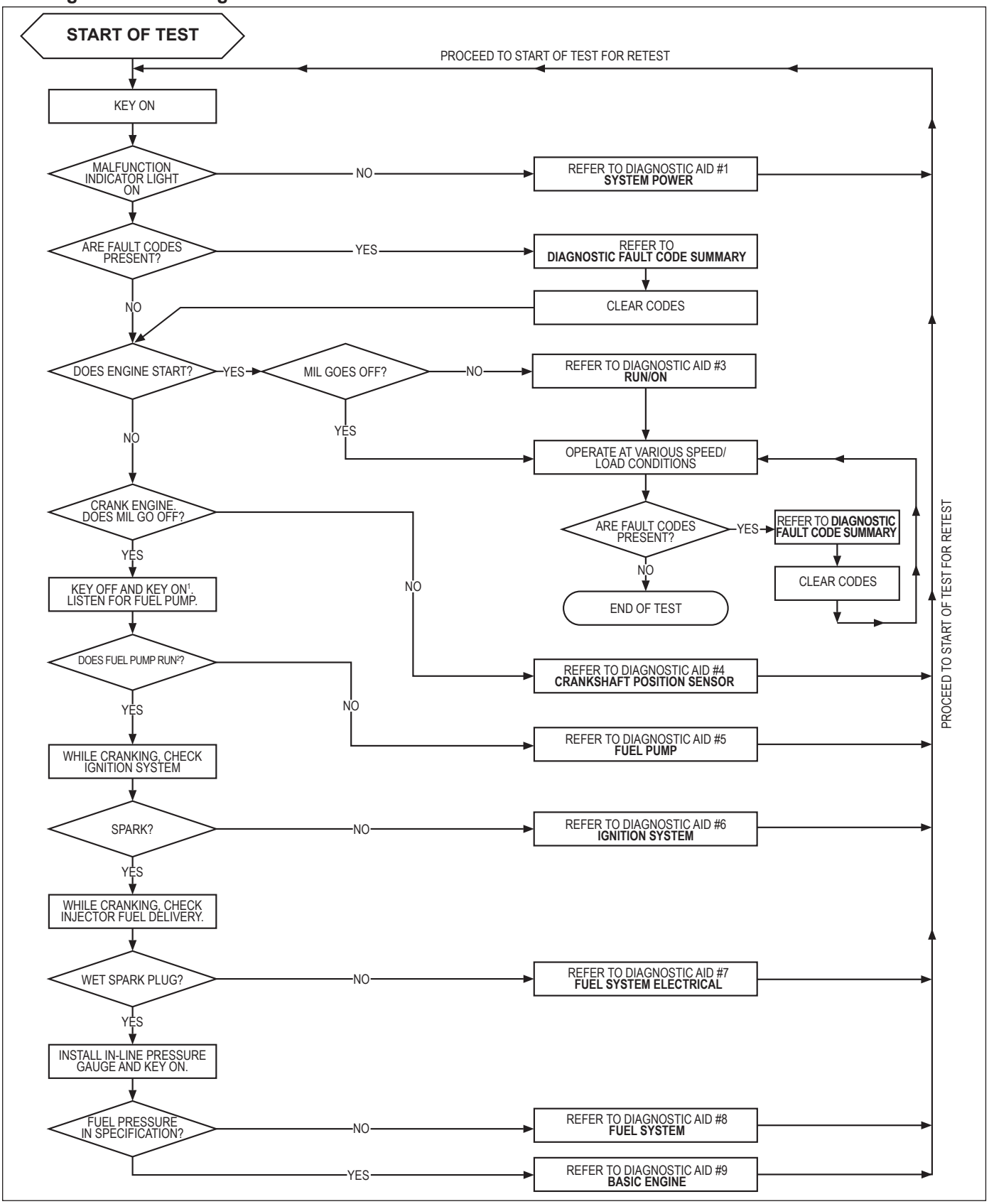
Diagnostic Aid #9 BASIC ENGINE

(cranks but will not run)

Condition

- Refer to basic engine troubleshooting charts within Troubleshooting.

EFI Diagnostic Flow Diagram



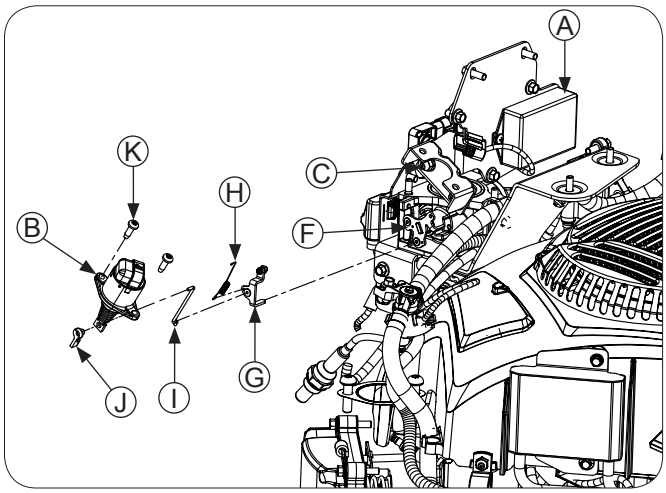
1. After turning key to OFF, wait 30 seconds before turning to ON to allow ECU to initiate another prime cycle.
2. Fuel pump module can be heard or a vibration can be felt to establish pump cycle. Fuel pump module will run for one 4-6 second prime cycle after key switch remains off for a minimum of 30 seconds.

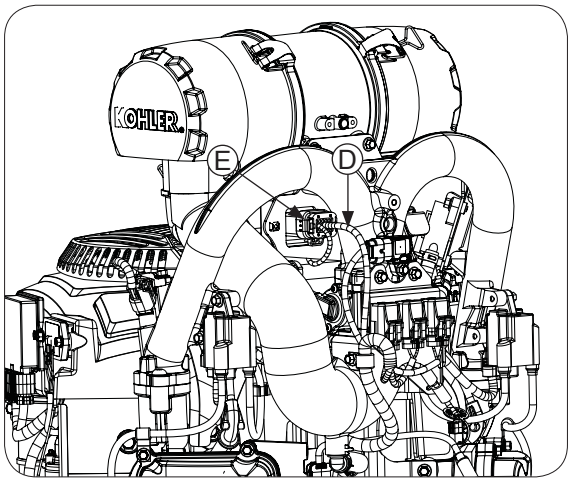
GOVERNOR

These engines are equipped with an electronic governor or a mechanical governor.

ELECTRONIC GOVERNOR

Components





A	Governor Control Unit (GCU)	**B**	Digital Linear Actuator (DLA)	**C**	DLA Bracket Mounting Nuts	**D**	Wiring Harness
E	Connector	**F**	Throttle Body Assembly	**G**	Throttle Body Lever Adapter	**H**	Linkage Spring
I	Throttle Linkage	**J**	Plastic Linkage Retaining Clip	**K**	DLA to DLA Bracket Mounting Screws		

Electronic governor regulates engine speed at varying loads. Typical electronic governor includes:

- Digital linear actuator (DLA).
- Throttle linkage.
- Linkage spring.
- Linkage retaining clip.
- Governor control unit (GCU).

Digital Linear Actuator (DLA)

Energizing bi-directional digital linear actuator coils in proper sequence, causes threaded shaft to move out of, or back into rotor, in precise linear increments. When power is removed, actuator shaft remains in position. DLA must initialize (fully extend) to move throttle plate to closed position, and partially open for starting. Correct adjustment of DLA is critical to achieve full range of throttle plate movement. See Adjustment.

Governor control unit (GCU) senses engine speed by pulse voltage inputs from EFI ECU module. GCU regulates engine speed by variable input voltage from a customer-supplied source.

NOTE: Actual speeds depend on application. Refer to equipment manufacturer's recommendations.

Potentiometer Specifications

Wiper Voltage	Engine Speed (RPM)
0-1	Low Speed Endpoint
1-9	Variable Speed Endpoint
9-16	High Speed Endpoint

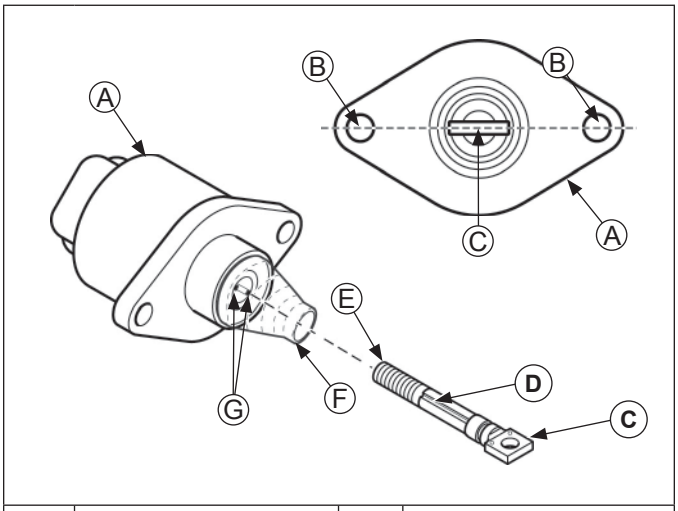
Linkage

NOTE: Throttle linkage spring must be in place and installed correctly to ensure proper throttle operation and performance.

Throttle linkage spring will fully open throttle plate if linkage becomes detached from DLA. This will create an overspeed condition causing engine to shut down. DLA shaft will have to be manually screwed back into body, and then retracted before reassembling linkage.

Adjustment

DLA Details



A	DLA	**B**	Mounting Holes
C	Clevis	**D**	Keyway
E	Clevis Shaft	**F**	Rubber Boot
G	Keys		

DLA must be in fully retracted position during assembly. Full range of throttle plate movement will not be achieved if DLA is partially extended when assembled. Loosen DLA mounting plate screws located on side of actuator plate. With throttle linkage secured with a retaining clip at end of DLA shaft, slide DLA bracket assembly back until throttle plate is fully open. Torque mounting nuts to 10.2 N·m (90 in. lb.).

Proper link/spring assembly is critical. Insert spring hook tab of spring through DLA clevis hole until it exits opposite side, and tab of spring is allowed to snap into position. Hook opposite “hook” end of spring through throttle body lever adapter hole before inserting z-bend of link into throttle body lever adapter. Pay close attention not to stretch/over extend spring or damage to spring may occur.

If clevis shaft becomes overextended or disconnected from actuator reinstall as follows:

1. Disconnect linkage and remove DLA from bracket.
2. Remove clevis shaft completely out of DLA.
3. Reinstall rubber boot onto DLA if required.
4. Place clevis shaft into actuator. Rotate clevis shaft clockwise 3 full turns, applying slight pressure, until you feel clevis shaft keyway make contact with key in actuator. When clevis shaft is installed properly flat of clevis will be aligned with two mounting holes.

NOTE: Continuing to rotate clevis shaft after it has made contact with keyway will damage keyway or actuator.

5. Confirm that key and keyway are in alignment, by hand, press clevis shaft into actuator. It will take a reasonable amount of pressure to do this. If shaft will not move inward, do not force it. Remove clevis shaft and repeat previous step.
6. Reinstall DLA into bracket, torque screws to 4.1 N·m (35 in. lb.), and connect linkage.

GCU/Harness Diagnostics and Troubleshooting

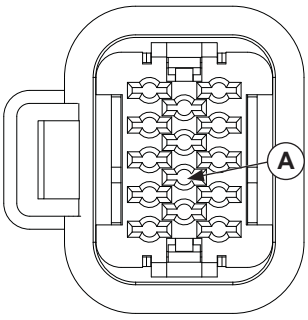
NOTE: It is important to use proper sized probes to perform these tests. Probes that are incorrect size can damage connector or harness plug.

Ground and Power Tests

1. Switch key to OFF position.
2. Remove GCU from bracket and unplug wiring harness.

These two tests check for power and ground supply to GCU. If either test fails, check if harness, electrical connections, or electrical system need repair.

Test 1 Probe Location

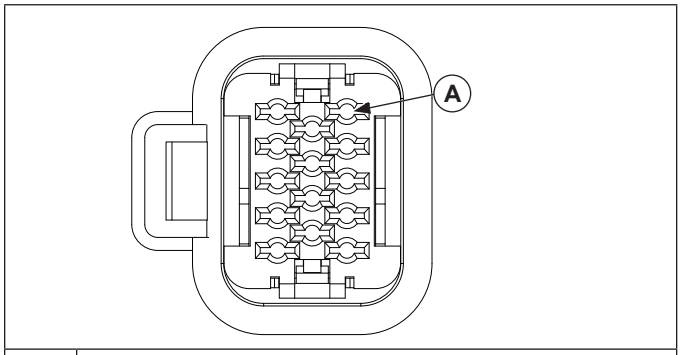


A	Probe Location for Ground Test 1.

Test 1: Identify probe location in connector. Using a continuity tester, check for a good ground. If ground is faulty, inspect unit ground, battery ground, connectors, and wiring harness. Clean or fix connections or replace any faulty parts.

If test 1 checks OK, locate probe location in connector, and check using test 2.

Test 2 Probe Location



A	Probe Location for Voltage Test 2.

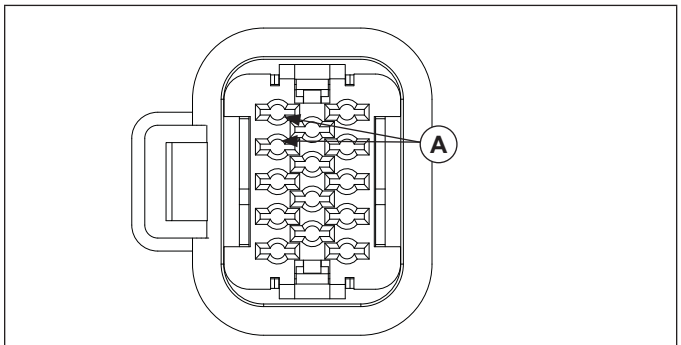
Test 2: Identify probe location in connector. Using a 12 volt meter test for voltage. Turn key switch to ON position. Voltage should be within +/- 1 volt of battery voltage. If voltage is within +/- 1 volt of battery voltage, harness is OK, replace GCU. If not within +/- 1 volt of battery voltage, check connections and replace wiring harness if necessary.

Ohms Tests

1. Remove GCU from bracket and unplug wiring harness.

These two tests are for measuring resistance of DLA circuit that sends a signal to GCU. If either test fails, DLA is no good and should be replaced. If both tests are good, DLA is neither shorted or open, it is good. Another component, connection, or input is most likely at fault.

Test 1 Probe Location

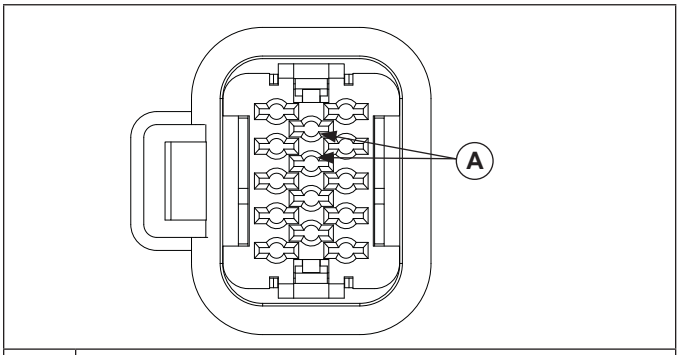


A	Probe Locations for OHMs Test 1.

Test 1: Identify probe locations in connector. Using a digital multi-meter set to lowest scale (0-200 ohms), place probes onto harness making sure of a good connection. Resistance should be between 47.7 and 58.3 ohms.

If test 1 checks OK, locate wire ends in connector and check using test 2.

Test 2 Probe Location

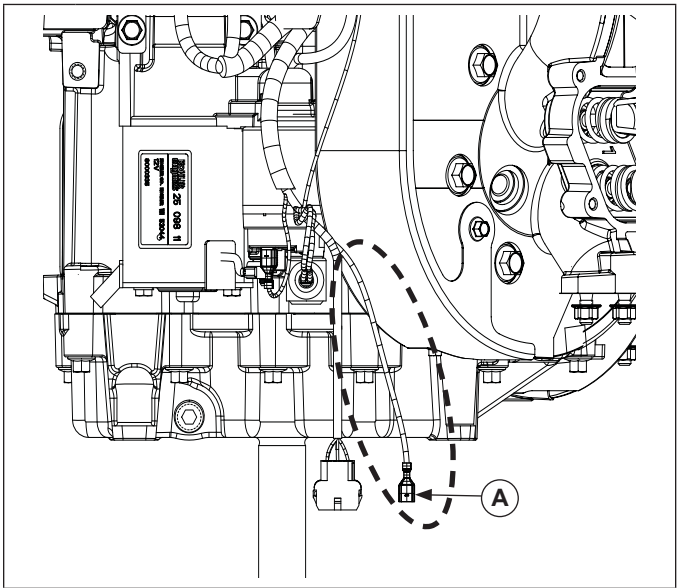


A	Probe Locations for OHMs Test 2.

Test 2: Identify probe locations in connector. Using a digital multi-meter set to lowest scale (0-200 ohms), place probes onto harness making sure of a good connection. Resistance should be between 47.7 and 58.3 ohms.

If either test 1 or 2 fail resistance test, fault could also be caused by a break/cut in wiring harness. Inspect and test for a potential harness issue prior to replacing DLA assembly.

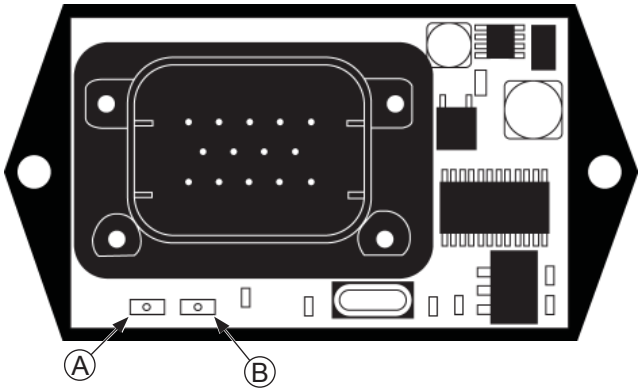
Speed Control Input



A	Red Wire with Yellow Tracer.

This connection is a single wire red with yellow tracer.

GCU Blink Code Tests



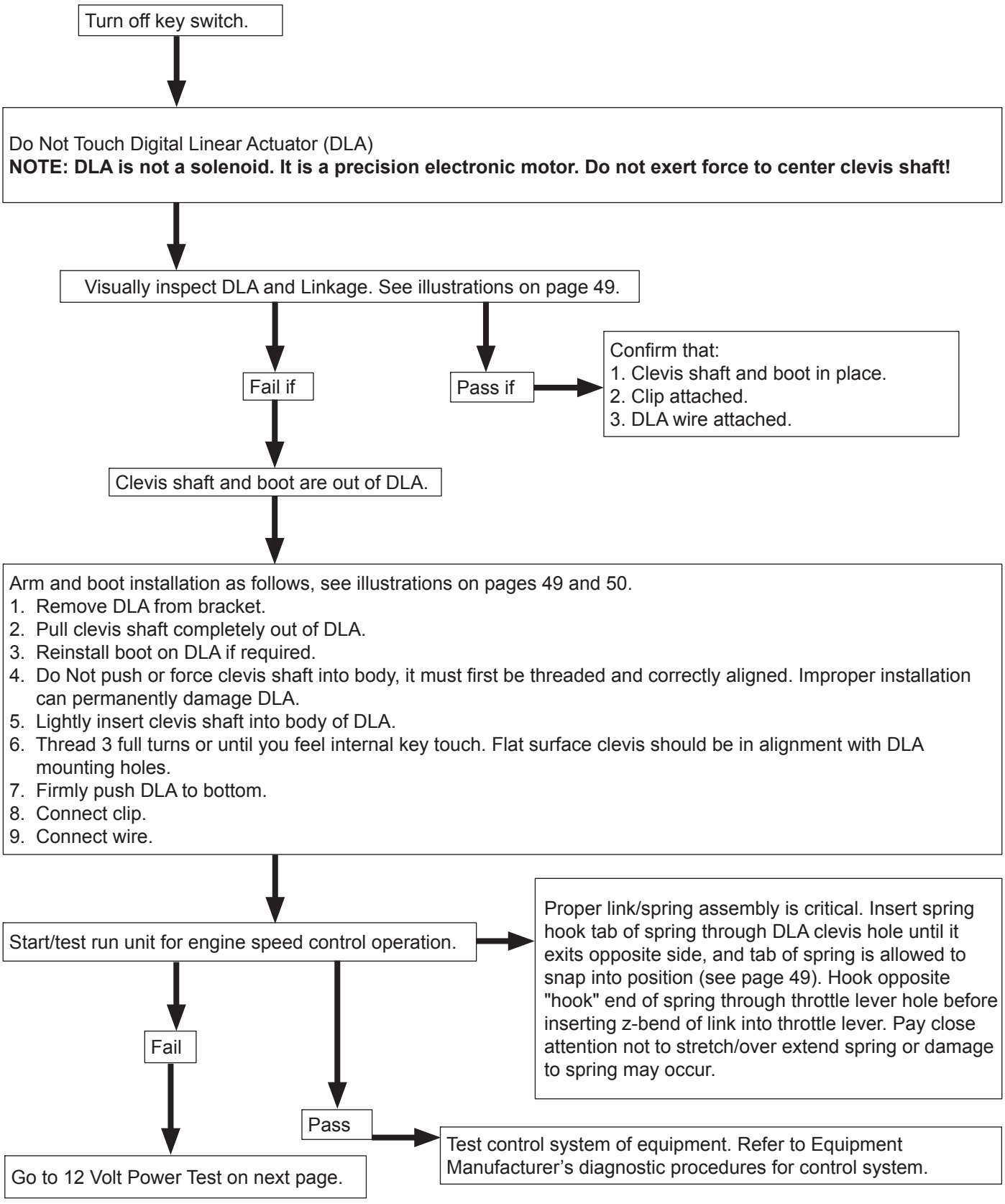
A	Green LED Light	**B**	Yellow LED Light

Speed control issues can also be diagnosed utilizing on-board Blink Code diagnostic lights equipped in GCU. These GCUs store blink codes/trouble codes, that can be quickly diagnosed using blink code charts.

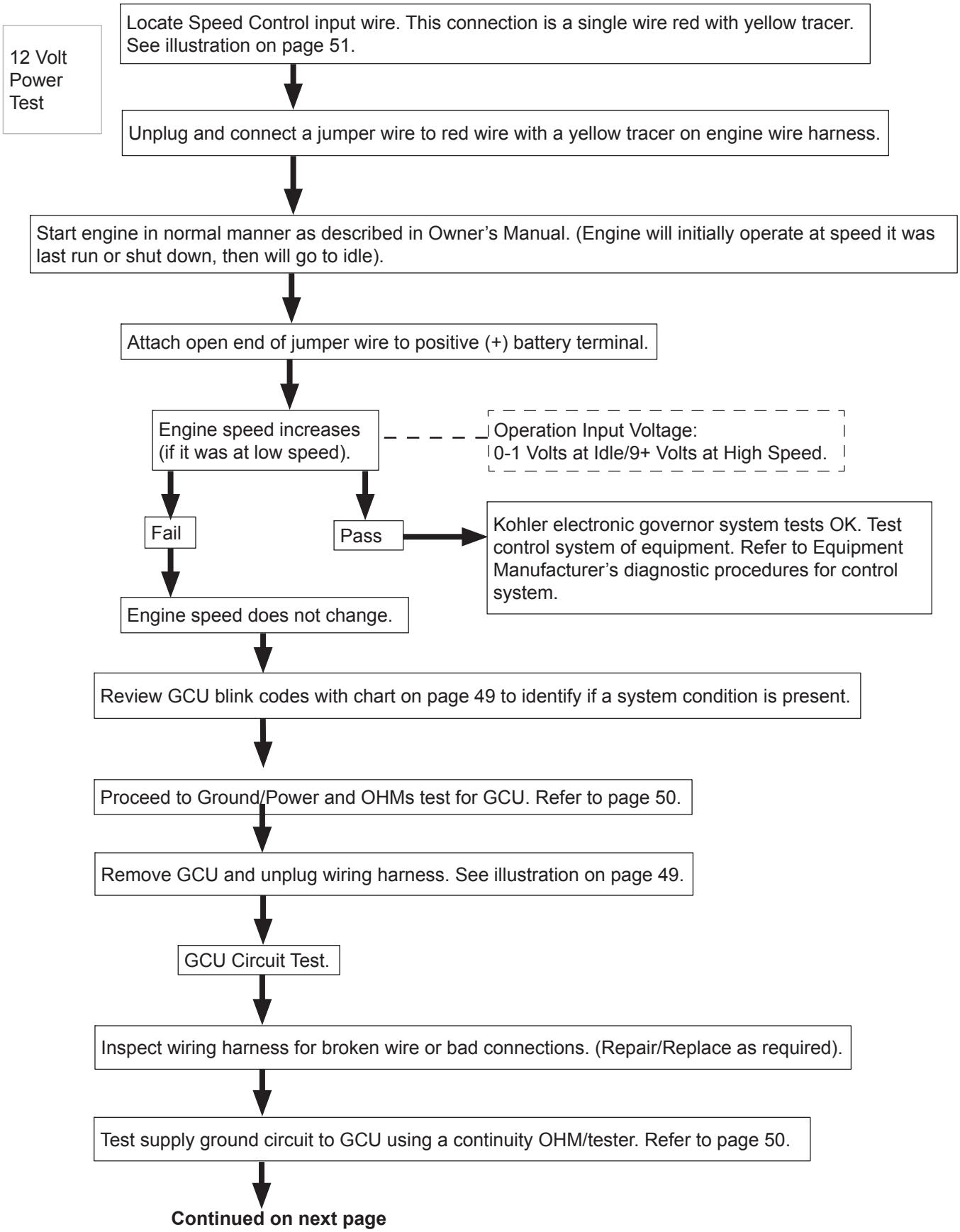
GCU Blink Codes for Software Stored Codes - Activated when key is turned to ON position.					
Failure Condition	**Possible Causes**	**Response**	**Response Time**	**LED Diagnostics**	
				Yellow LED	**Green LED**
Speed Error				BLINKS	ON
Watchdog Interrupt	RFI interference	Ground to kill, close throttle plate		BLINKS	BLINKS
	Overtemp				
	Software bug				
	Lightning				
Overspeed (Over 4500 RPM for 0.5 seconds sustained)	External noise on ECU input	Ground to kill, close throttle plate	1 second delay	ON	ON
	Frozen throttle plate				
	DLA failure				
	Mechanical bindage				
Excessive Battery Voltage (> 18v for 0.5 seconds)	Open battery voltage on B+ 24 V battery (not compatible with system, 12 V battery only)	Ground to kill, close throttle plate	0.5 seconds	OFF	ON

GCU Blink Codes for Software Running Codes - Activated when engine is running.					
Failure Condition	**Possible Causes**	**Response**	**Response Time**	**LED Diagnostics**	
				Yellow LED	**Green LED**
Running Normally		None		BLINKS	BLINKS
RPM Too High	Mechanical bindage	None		ON	BLINKS
RPM Too Low	Mechanical bindage	None		ON	BLINKS
Missing Pulse (Normal RPM)	Faulty ECU Faulty ECU wiring			BLINKS	ON
Missing Pulse (RPM Too High)	Faulty ECU Faulty ECU wiring			ON	ON
Missing Pulse (RPM Too Low)	Faulty ECU Faulty ECU wiring			OFF	ON
Sleep Mode	Power at GCU with no ECU pulses (left in run mode)	System shutdown	30 minutes	OFF	OFF
Watchdog Interrupt	RFI interference	Ground to kill, close throttle plate	N/A	BLINKS	OFF
	Overtemp				
	Software bug				
	Lightning				
Overspeed (Over 4500 RPM for 0.5 seconds sustained)	External noise on ECU input				
	Frozen throttle plate				
	DLA failure				
	Mechanical bindage		1 second delay	ON	OFF
Excessive Battery Voltage (> 18v for 0.5 seconds)	Open battery voltage on B+ 24 V battery (not compatible with system, 12 V battery only)	Ground to kill, close throttle plate	0.5 seconds	OFF	OFF

Electronic Governor Troubleshooting Flow Chart


Turn off key switch.
Do Not Touch Digital Linear Actuator (DLA)
NOTE: DLA is not a solenoid. It is a precision electronic motor. Do not exert force to center clevis shaft!
Visually inspect DLA and Linkage. See illustrations on page 49.
Fail if
Pass if
Confirm that:
1. Clevis shaft and boot in place.
2. Clip attached.
3. DLA wire attached.
Clevis shaft and boot are out of DLA.
Arm and boot installation as follows, see illustrations on pages 49 and 50.
1. Remove DLA from bracket.
2. Pull clevis shaft completely out of DLA.
3. Reinstall boot on DLA if required.
4. Do Not push or force clevis shaft into body, it must first be threaded and correctly aligned. Improper installation can permanently damage DLA.
5. Lightly insert clevis shaft into body of DLA.
6. Thread 3 full turns or until you feel internal key touch. Flat surface clevis should be in alignment with DLA mounting holes.
7. Firmly push DLA to bottom.
8. Connect clip.
9. Connect wire.
Start/test run unit for engine speed control operation.
Proper link/spring assembly is critical. Insert spring hook tab of spring through DLA clevis hole until it exits opposite side, and tab of spring is allowed to snap into position (see page 49). Hook opposite "hook" end of spring through throttle lever hole before inserting z-bend of link into throttle lever. Pay close attention not to stretch/over extend spring or damage to spring may occur.
Fail
Pass
Test control system of equipment. Refer to Equipment Manufacturer's diagnostic procedures for control system.
Go to 12 Volt Power Test on next page.

Electronic Governor Troubleshooting Flow Chart Continued


12 Volt Power Test
Locate Speed Control input wire. This connection is a single wire red with yellow tracer. See illustration on page 51.
Unplug and connect a jumper wire to red wire with a yellow tracer on engine wire harness.
Start engine in normal manner as described in Owner's Manual. (Engine will initially operate at speed it was last run or shut down, then will go to idle).
Attach open end of jumper wire to positive (+) battery terminal.
Engine speed increases (if it was at low speed).
Operation Input Voltage: 0-1 Volts at Idle/9+ Volts at High Speed.
Fail
Pass
Kohler electronic governor system tests OK. Test control system of equipment. Refer to Equipment Manufacturer's diagnostic procedures for control system.
Engine speed does not change.
Review GCU blink codes with chart on page 49 to identify if a system condition is present.
Proceed to Ground/Power and OHMs test for GCU. Refer to page 50.
Remove GCU and unplug wiring harness. See illustration on page 49.
GCU Circuit Test.
Inspect wiring harness for broken wire or bad connections. (Repair/Replace as required).
Test supply ground circuit to GCU using a continuity OHM/tester. Refer to page 50.

Continued on next page

Electronic Governor Troubleshooting Flow Chart Continued

Turn key switch to ON position. Test supply voltage to GCU using volt meter. Refer to page 50 (battery voltage +/- 1 volt) **Note: Prevent Damage to Connector. Do Not Use Oversized Probe Tips.**

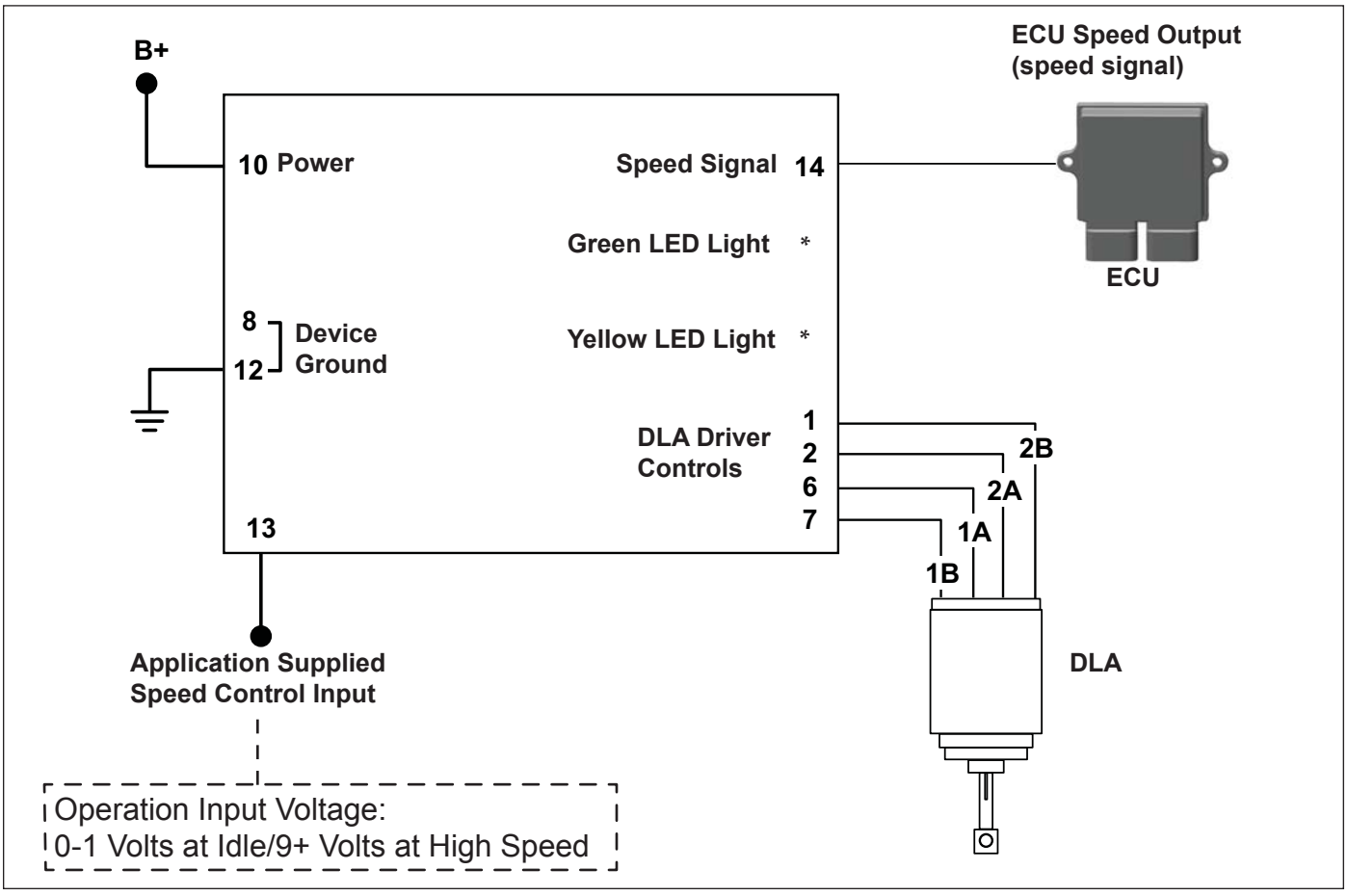
Proceed to DLA Circuit Test.

Test 1: Identify wire ends in connector. Using a digital multi-meter set to lowest scale (0-200 ohms) place probes onto harness making sure of a good connection. Resistance should be between 47.7 and 58.3 ohms. Refer to page 51.

Test 2: Identify wire ends in connector. Using a digital multi-meter set to lowest scale (0-200 ohms) place probes onto harness making sure of a good connection. Resistance should be between 47.7 and 58.3 ohms. Refer to page 51.

If either test fails, DLA is no good and should be replaced. If both tests are good, DLA is neither shorted or open, and should be good. Another component, connection, or input is most likely at fault.

Basic Electrical Diagram of Electronic Governor System

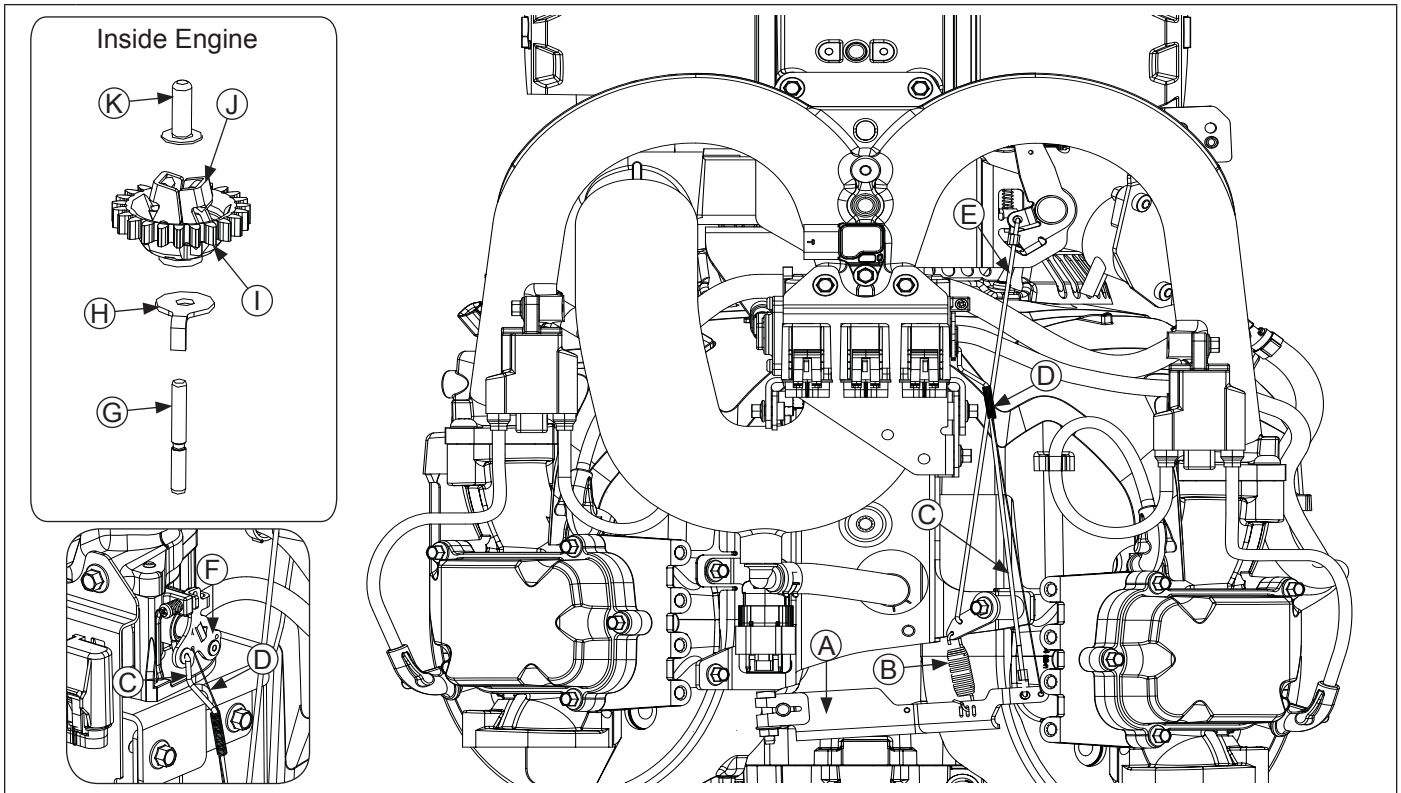


MECHANICAL GOVERNOR

Governed speed setting is determined by position of throttle control. It can be variable or constant, depending on engine application.

Governor is designed to hold engine speed constant under changing load conditions. Governor gear/flyweight mechanism is mounted inside oil pan and is driven off gear on camshaft.

Components

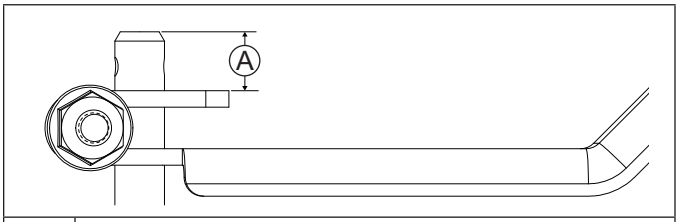


A	Governor Lever	**B**	Governor Spring	**C**	Governor Linkage	**D**	Linkage Spring
E	Speed Control Linkage	**F**	Throttle Lever	**G**	Governor Gear Shaft	**H**	Locking Tab Thrust Washer
I	Governor Gear	**J**	Flyweight	**K**	Regulating Pin		

This governor design works as follows:

- Centrifugal force acting on rotating governor gear assembly causes flyweights to move outward as speed increases. Governor spring tension moves them inward as speed decreases.
- As flyweights move outward, they cause regulating pin to move outward.
- Regulating pin contacts tab on cross shaft causing shaft to rotate.
- One end of cross shaft protrudes through crankcase. Rotating action of cross shaft is transmitted to throttle lever of throttle body through external linkage.
- When engine is at rest, and throttle is in FAST position, tension of governor spring holds throttle plate open. When engine is operating, governor gear assembly is rotating. Force applied by regulating pin against cross shaft tends to close throttle plate. Governor spring tension and force applied by regulating pin balance each other during operation, to maintain engine speed.
- When load is applied and engine speed and governor gear speed decreases, governor spring tension moves governor lever to open throttle plate wider. This allows more fuel into engine, increasing engine speed. As speed reaches governed setting, governor spring tension and force applied by regulating pin will again offset each other to hold a steady engine speed.

Governor Adjustments



A	9.5 mm ± 0.5 (0.37 in. ± 0.02)

NOTE: Do not tamper with governor setting. Overspeed is hazardous and could cause personal injury.

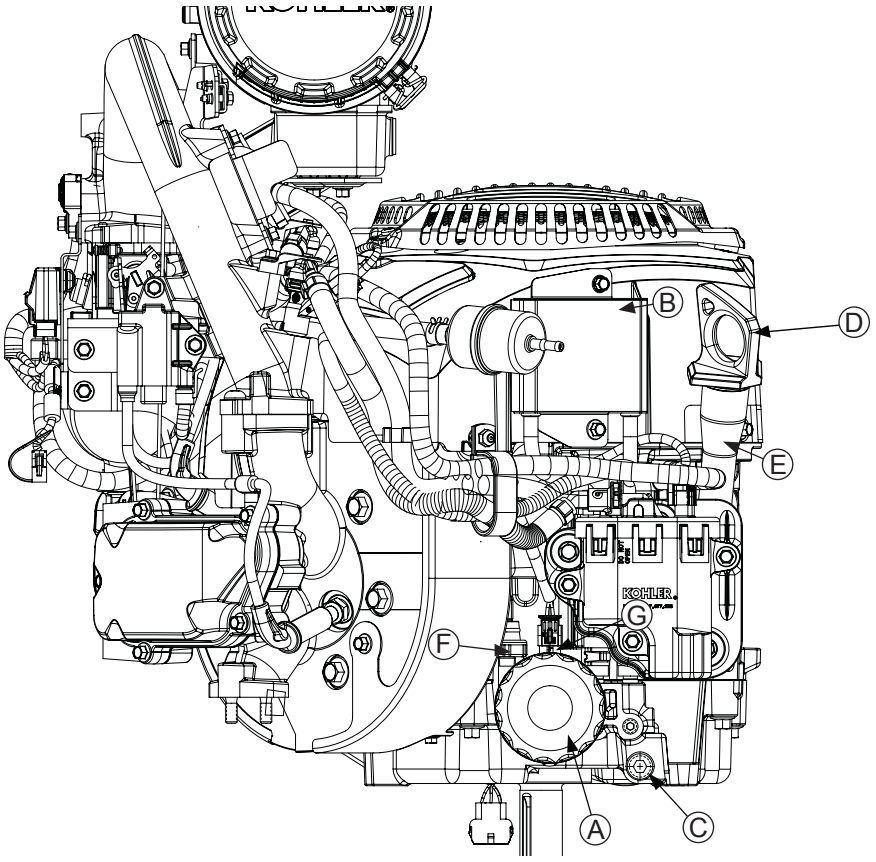
Initial Adjustment Procedure
Make this adjustment whenever governor arm is loosened or removed from cross shaft. Adjust as follows:

1. Make sure governor linkage is connected to governor lever and throttle lever on throttle body.
2. Loosen nut holding governor lever to cross shaft.
3. Move governor lever toward throttle body as far as it will go (wide open throttle) and hold in this position.
4. Insert a long thin rod or tool into hole on cross shaft and rotate shaft counterclockwise (viewed from end) as far as it will turn.
5. Adjust governor lever to maintain correct location from end of governor cross shaft. Torque nut to 7.1 N·m (63 in. lb.).

This engine uses a full pressure lubrication system which delivers oil under pressure to crankshaft, camshaft, and connecting rod bearing surfaces.

A high-efficiency gerotor oil pump maintains high oil flow and oil pressure, even at low speeds and high operating temperatures. A pressure relief valve limits maximum pressure of system. Oil pan must be removed to service oil governor gear and oil pump.

Lubrication Components



A	Oil Filter	**B**	Oil Cooler (if equipped)	**C**	Oil Drain Plug	**D**	Oil Fill/Dipstick	**E**	Oil Fill Tube
F	Pressure Switch	**G**	Oil Temperature Switch						

OIL RECOMMENDATIONS

Refer to Maintenance.

CHECK OIL LEVEL

NOTE: To prevent extensive engine wear or damage, never run engine with oil level below or above operating range indicator on dipstick.

Ensure engine is cool. Clean oil fill/dipstick areas of any debris.

1. Remove dipstick; wipe oil off.
2. Reinsert dipstick into tube; press completely down.
3. Remove dipstick; check oil level. Level should be at top of indicator on dipstick.
4. If oil is low on indicator, add oil up to top of indicator mark.
5. Reinstall and secure dipstick.

CHANGE OIL AND FILTER

Change oil while engine is warm.

1. Clean area around oil fill cap/dipstick and drain plug. Remove drain plug and oil fill cap/dipstick. Allow oil to drain completely.
2. Clean area around oil filter; remove filter; wipe off mounting surface. Reinstall drain plug and torque to 21.4 N·m (15.7 ft. lb.).
3. Place new filter in shallow pan with open end up. Fill with new oil until oil reaches bottom of threads. Allow 2 minutes for oil to be absorbed by filter material.
4. Apply a thin film of clean oil to rubber gasket on new filter.
5. Refer to instructions on oil filter for proper installation.
6. Fill crankcase with new oil. Level should be at top of indicator on dipstick.

7. Reinstall oil fill cap/dipstick and tighten securely.
8. Start engine; check for oil leaks. Stop engine; correct leaks. Recheck oil level.
9. Dispose of used oil and filter in accordance with local ordinances.

OIL COOLER (if equipped)

1. Clean fins with a brush or compressed air.
2. Remove screws securing oil cooler and tilt to clean back side.
3. Reinstall oil cooler and torque top screw (M5) to 5.6 N·m (50 in. lb.) and bottom screw (M6) to 4.8 N·m (46 in. lb.).

OIL SENTRY™ (if equipped)

This switch is designed to prevent engine from starting in a low oil or no oil condition. Oil Sentry™ may not shut down a running engine before damage occurs. In some applications this switch may activate a warning signal. Read your equipment manuals for more information.

Oil Sentry™ pressure switch is installed in oil pan pressure port. On engines not equipped with Oil Sentry™ installation hole is sealed with a 1/8-27 N.P.T.F. pipe plug.

Installation

1. Apply pipe sealant with Teflon® (Loctite® PST® 592™ Thread Sealant or equivalent) to threads of switch.
2. Install switch into tapped hole in oil pan.
3. Torque switch to 9 N·m (80 in. lb.).

Testing

Compressed air, a pressure regulator, pressure gauge, and a continuity tester are required to test switch.

Normally Open Switch

1. Connect continuity tester across blade terminal and metal case of switch. With 0 psi pressure applied to switch, tester should indicate no continuity (switch open).
2. Gradually increase pressure to switch. As pressure increases through range of 2.0/5.0 psi, tester should indicate a change to continuity (switch closed). Switch should remain closed as pressure is increased to 90 psi maximum.
3. Gradually decrease pressure through range of 2.0/5.0 psi. Tester should indicate a change to no continuity (switch open) down to 0 psi.
4. Replace switch if it does not operate as specified.

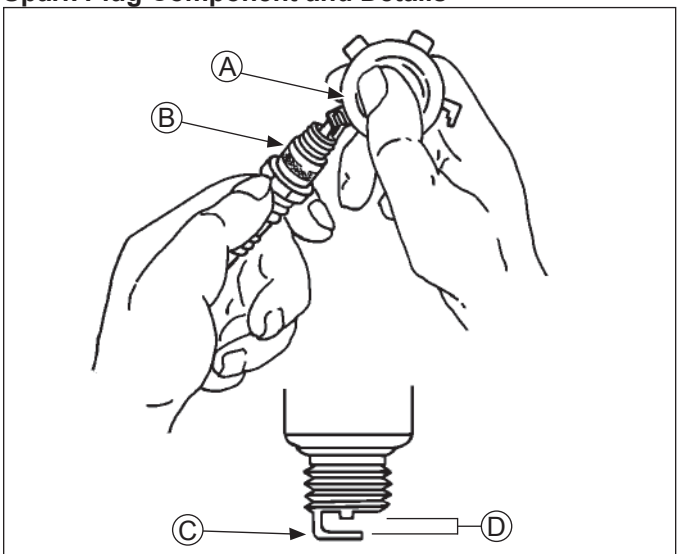
Normally Closed Switch

1. Connect continuity tester across blade terminal and metal case of switch. With 0 psi pressure applied to switch, tester should indicate continuity (switch closed).
2. Gradually increase pressure to switch. As pressure increases through range of 2.0/5.0 psi, tester should indicate a change to no continuity (switch open). Switch should remain open as pressure is increased to 90 psi maximum.
3. Gradually decrease pressure through range of 2.0/5.0 psi. Tester should indicate a change to continuity (switch closed) down to 0 psi.
4. Replace switch if it does not operate as specified.

SPARK PLUGS

	⚠ CAUTION Electrical Shock can cause injury. Do not touch wires while engine is running.

Spark Plug Component and Details



A	Wire Gauge	**B**	Spark Plug
C	Ground Electrode	**D**	Gap

NOTE: Do not clean spark plug in a machine using abrasive grit. Some grit could remain in spark plug and enter engine causing extensive wear and damage.

Engine misfire or starting problems are often caused by a spark plug that has improper gap or is in poor condition.

Engine is equipped with following spark plugs:

Gap	0.76 mm (0.03 in.)
Thread Size	12 mm
Reach	19.1 mm (3/4 in.)
Hex Size	15.9 mm (5/8 in.)

Refer to Maintenance for Repairs/Service Parts.

Service

Clean out spark plug recess. Remove plug and replace.

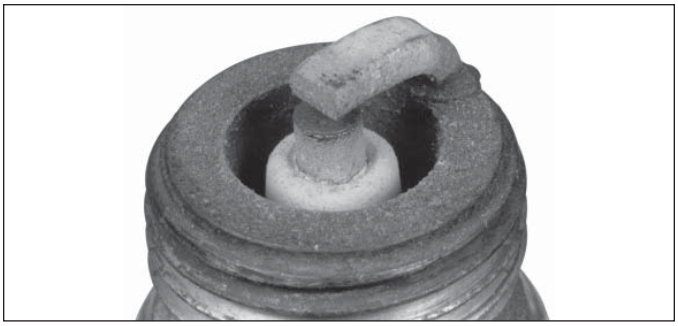
1. Check gap using wire feeler gauge. Adjust gap to 0.76 mm (0.03 in.).
2. Install plug into cylinder head.
3. Torque plug to 27 N·m (20 ft. lb.).

Inspection

Inspect each spark plug as it is removed from cylinder head. Deposits on tip are an indication of general condition of piston rings, valves, and carburetor.

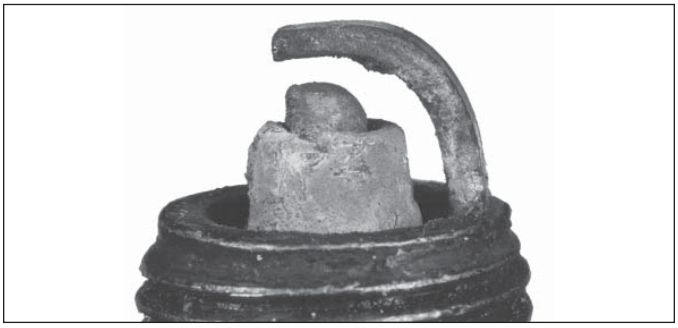
Normal and fouled plugs are shown in following photos:

Normal



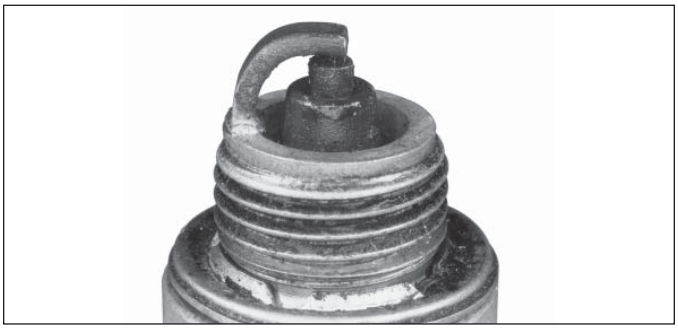
Plug taken from an engine operating under normal conditions will have light tan or gray colored deposits. If center electrode is not worn, plug can be set to proper gap and reused.

Worn



On a worn plug, center electrode will be rounded and gap will be greater than specified gap. Replace a worn spark plug immediately.

Wet Fouled



A wet plug is caused by excess fuel or oil in combustion chamber. Excess fuel could be caused by a restricted air cleaner, a carburetor problem, or operating engine with too much choke. Oil in combustion chamber is usually caused by a restricted air cleaner, a breather problem, worn piston rings, or valve guides.

Carbon Fouled

Soft, sooty, black deposits indicate incomplete combustion caused by a restricted air cleaner, over rich carburetion, weak ignition, or poor compression.

Overheated

Chalky, white deposits indicate very high combustion temperatures. This condition is usually accompanied by excessive gap erosion. Lean carburetor settings, an intake air leak, or incorrect spark timing are normal causes for high combustion temperatures.

BATTERY

A 12-volt battery with 400 cold cranking amps (cca) is generally recommended for starting in all conditions. A smaller capacity battery is often sufficient if an application is started only in warmer temperatures. Refer to following table for minimum capacities based on anticipated ambient temperatures. Actual cold cranking requirement depends on engine size, application, and starting temperatures. Cranking requirements increase as temperatures decrease and battery capacity shrinks. Refer to equipment's operating instructions for specific battery requirements.

Battery Size Recommendations

Temperature	Battery Required
Above 32°F (0°C)	200 cca minimum
0°F to 32°F (-18°C to 0°C)	250 cca minimum
-5°F to 0°F (-21°C to -18°C)	300 cca minimum
-10°F (-23°C) or below	400 cca minimum

If battery charge is insufficient to turn over engine, recharge battery.

Battery Maintenance

Regular maintenance is necessary to prolong battery life.

Battery Test

To test battery, follow manufacturer's instructions.

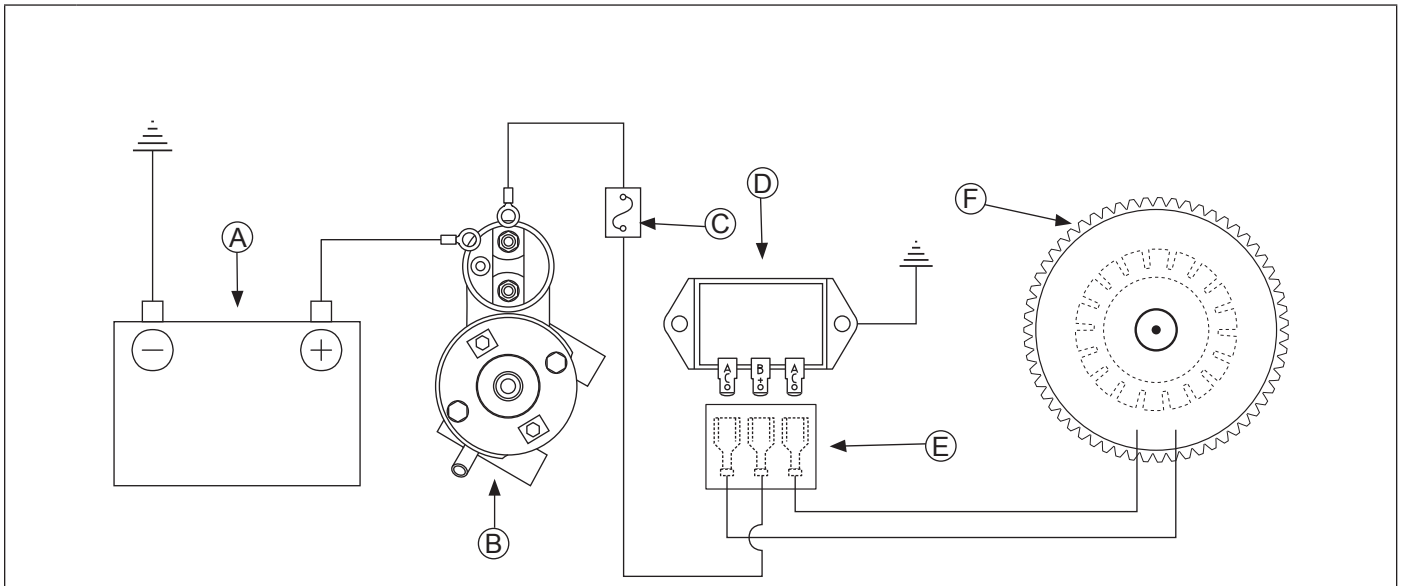
BATTERY CHARGING SYSTEM

NOTE: Observe following guidelines to avoid damage to electrical system and components:

- Make sure battery polarity is correct. A negative (-) ground system is used.
- Disconnect rectifier-regulator plug and/or wiring harness plug before doing any electric welding on equipment powered by engine. Also, disconnect all other electrical accessories in common ground with engine.
- Prevent stator (AC) leads from touching or shorting while engine is running. This could damage stator.

These engines are equipped with a 20 or 25 amp regulated charging system.

20/25 Amp Regulated Charging System



A	Battery	**B**	Starter	**C**	Fuse	**D**	Rectifier-Regulator
E	Connector Block	**F**	Flywheel Stator Assembly				

Stator

Stator is mounted on crankcase behind flywheel. Follow procedures in Disassembly and Reassembly if stator replacement is necessary.

Rectifier-Regulator

NOTE: When installing rectifier-regulator, take note of terminal markings and install plug(s) accordingly.

NOTE: Disconnect all electrical connections attached to rectifier-regulator. Testing may be performed with rectifier-regulator mounted or loose. Repeat applicable test procedure 2 or 3 times to determine condition of part.

Rectifier-regulator is mounted on blower housing. To replace, disconnect plug(s), remove mounting screws, and ground wire or metal grounding strap.

Testing rectifier-regulator may be performed as follows, using appropriate rectifier-regulator tester.

To test 20/25 amp rectifier-regulators:

1. Connect tester ground lead (with spring clamp) to body of rectifier-regulator.
2. Connect red lead from tester to middle terminal labeled B+.
3. Connect black leads from tester to both outer AC terminals on rectifier-regulator.
4. Plug tester into proper AC outlet/power for tester being used. Turn on power switch. POWER light should be illuminated and one of four status lights may be lit as well. This does not represent condition of part.
5. Press TEST button until a click is heard and then release. Momentarily one of four status lights will illuminate indicating partial condition of part.

Condition	Conclusion
	20/25 amp
OK (green) light comes on and stays steady.	Disconnect tester black lead attached to 1 AC terminal and reconnect it to other AC terminal. Repeat test. If OK (green) light comes on again, part is good and may be used.

NOTE: A flashing LOW light can also occur as a result of an inadequate ground lead connection. Make certain connection location is clean and clamp is secure. Other lights come on.	Rectifier-regulator is faulty and should not be used.

Troubleshooting Guide

20/25 Amp Battery Charging System

NOTE: Always zero ohmmeter on each scale before testing to ensure accurate readings. Voltage tests should be made with engine running at 3600 RPM - no load. Battery must be good and fully charged.

When problems occur in keeping battery charged or battery charges at too high a rate, problem can usually be found somewhere in charging system or with battery.

To test charging system for no charge to battery:

1. Insert an ammeter in B+ lead from rectifier-regulator. With engine running at 3600 RPM and B+ (at terminal on rectifier-regulator) to ground using a DC voltmeter.

   If voltage is 13.8 volts or more, place a minimum load of 5 amps (turn on lights if 60 watts or more, or place a 2.5 ohm, 100 watt resistor across battery terminals) on battery to reduce voltage. Observe ammeter.

Condition	Conclusion
Charge rate increases when load is applied.	Charging system is OK and battery was fully charged.
Charge rate does not increase when load is applied.	Test stator and rectifier-regulator (steps 2 and 3).

2. Remove connector from rectifier-regulator. With engine running at 3600 RPM, measure AC voltage across stator leads using an AC voltmeter.

Condition	Conclusion
Voltage is 28 volts or more.	Stator is OK. Rectifier-regulator is faulty; replace.
Voltage is less than 28 volts.	Stator is faulty; replace. Test stator further using an ohmmeter (steps 3 and 4).

3. With engine stopped, measure resistance across stator leads using an ohmmeter.

Condition	Conclusion
Resistance is 0.064/0.2 ohms.	Stator is OK.
Resistance is 0 ohms.	Stator is shorted; replace.
Resistance is infinity ohms.	Stator is open; replace.

4. With engine stopped, measure resistance from each stator lead to ground using an ohmmeter.

Condition	Conclusion
Resistance is infinity ohms (no continuity).	Stator is OK (not shorted to ground).
Resistance (or continuity) measured.	Stator leads are shorted to ground; replace.

To test charging system for battery continuously charging at high rate:

1. With engine running at 3600 RPM, measure voltage from B+ lead to ground using a DC voltmeter.

Condition	Conclusion
Voltage is 14.7 volts or less.	Charging system is OK. Battery is unable to hold charge; service or replace.
Voltage is more than 14.7 volts.	Faulty rectifier-regulator; replace.

FUSES

This engine has 3 blade type automotive fuses. Replacement fuses must have same rating as blown fuse. Use fuse chart below to determine correct fuse.

Wire Color	Fuse Rating
2 Purple Wires	30-amp Fuse
1 Red Wire w/ Black Stripe 1 Red Wire w/ White Stripe	10-amp Fuse
2 Red Wires	10-amp Fuse

Fuse Replacement

1. Shut engine off and remove key.
2. Locate fuse holders.
3. Remove fuse cover and pull out fuse.
4. Inspect fuse for a solid fusible link or a broken fusible link. Replace fuse if fusible link is broken. If you are not sure if fusible link is broken, replace fuse.
5. Insert fuse into fuse holder until it is seated properly. Install fuse cover.

Starter System

NOTE: Do not crank engine continuously for more than 10 seconds. Allow a 60 second cool down period between starting attempts. Failure to follow these guidelines can burn out starter motor.

NOTE: If starter is engaged while flywheel is rotating, starter pinion and flywheel ring gear may clash and damage starter.

NOTE: If starter does not crank engine, shut off starter immediately. Do not make further attempts to start engine until condition is corrected.

NOTE: Do not drop starter or strike starter frame. Doing so can damage starter.

Engines in this series use solenoid shift starters.

Troubleshooting-Starting Difficulties

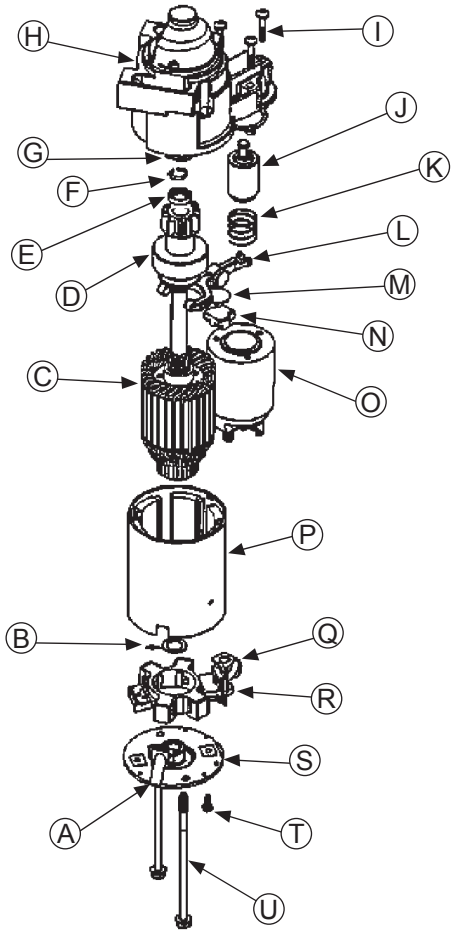
Condition	Possible Cause	Conclusion
Starter does not energize.	Battery	Check specific gravity of battery. If low, recharge or replace battery as necessary.
	Wiring	Clean corroded connections and tighten loose connections. Replace wires in poor condition and with frayed or broken insulation.
	Starter Switch or Solenoid	By-pass switch or solenoid with a jumper wire. If starter cranks normally, replace faulty components. Remove and perform individual solenoid test procedure.
Starter energizes but turns slowly.	Battery	Check specific gravity of battery. If low, recharge or replace battery as necessary.
	Brushes	Check for excessively dirty or worn brushes and commutator. Clean using a coarse cloth (not emery cloth). Replace brushes if excessively or unevenly worn.
	Transmission or Engine	Make sure clutch or transmission is disengaged or placed in neutral. This is especially important on equipment with hydrostatic drive. Transmission must be exactly in neutral to prevent resistance which could keep engine from starting. Check for seized engine components such as bearings, connecting rod, and piston.

SOLENOID SHIFT STARTERS

When power is applied to starter electric solenoid moves drive pinion out onto drive shaft and into mesh with flywheel ring gear. When pinion reaches end of drive shaft it rotates flywheel and cranks engine.

When engine starts and start switch is released, starter solenoid is deactivated, drive lever moves back, and drive pinion moves out of mesh with ring gear into retracted position.

Solenoid Shift Starter Components



A	Tube	**B**	Washer
C	Armature	**D**	Drive
E	Stop	**F**	Retaining Ring
G	Collar	**H**	Drive End Cap
I	Screw	**J**	Plunger
K	Spring	**L**	Lever
M	Plate	**N**	Plug
O	Solenoid	**P**	Frame and Field
Q	Brush Holder	**R**	Nut
S	Commutator End Plate	**T**	Screw
U	Bolt		

Starter Disassembly

NOTE: Do not reuse old retainer.

NOTE: Do not soak armature or use solvent when cleaning. Wipe clean using a soft cloth, or use compressed air.

1. Remove hex nut and disconnect positive (+) brush lead/bracket from solenoid terminal.
2. Remove head screws securing solenoid to starter.
3. Unhook plunger pin from drive lever. Remove gasket from recess in housing.
4. Remove thru (larger) bolts.
5. Remove commutator end plate assembly, containing brush holder, brushes, springs, and locking caps. Remove thrust washer from inside commutator end.
6. Remove frame from armature and drive end cap.
7. Remove drive lever pivot bushing and backing plate (if equipped) from end cap.
8. Take out drive lever and pull armature out of drive end cap.
9. Remove thrust washer from armature shaft.
10. Push stop collar down to expose retaining ring.
11. Remove retainer from armature shaft. Save stop collar.
12. Remove drive pinion assembly from armature.
13. Clean parts as required.

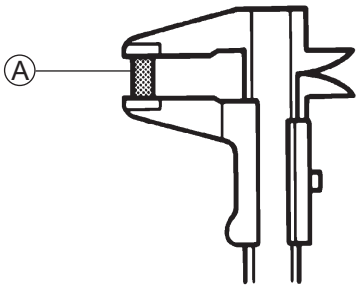
Inspection

Drive Pinion

Check and inspect following areas:

- Pinion teeth for abnormal wear or damage.
- Surface between pinion and clutch mechanism for nicks or irregularities which could cause seal damage.
- Check drive clutch by holding clutch housing and rotating pinion. Pinion should rotate in only 1 direction.

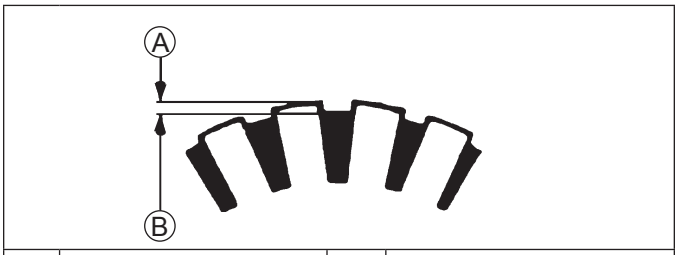
Brushes and Springs
Detail



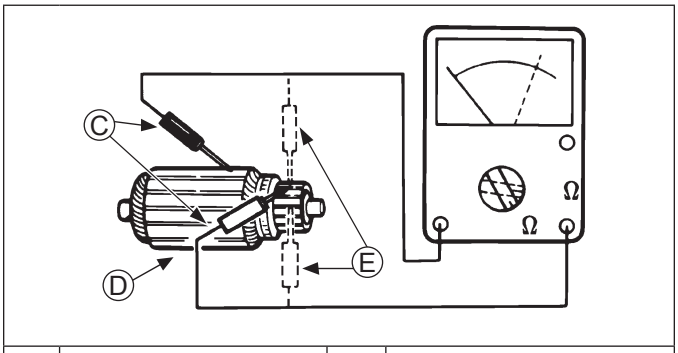
A	Wear Limit Length

Inspect both springs and brushes for wear, fatigue, or damage. Measure length of each brush. Minimum length for each brush is 7.6 mm (0.300 in.). Replace brushes if they are worn, undersize, or condition is questionable.

Armature
Components and Details



A	Commutator O.D.	**B**	Mica Insulation



C	Insulation Check	**D**	Armature Coil
E	Continuity Check		

1. Clean and inspect commutator (outer surface). Mica insulation must be lower than commutator bars (undercut) to ensure proper operation of commutator.
2. Use an ohmmeter set to Rx1 scale. Touch probes between 2 different segments of commutator, and check for continuity. Test all segments. Continuity must exist between all or armature is bad.
3. Check for continuity between armature coil segments and commutator segments. There should be no continuity. If continuity exists between any 2 armature is bad.
4. Check armature windings/insulation for shorting.

Shift Fork
Check that shift fork is complete, and pivot and contact areas are not excessively worn, cracked, or broken.

Brush Replacement

4 brushes and springs are serviced as a set. Use a new Kohler brush and spring kit if replacement is necessary.

1. Perform steps 1-5 in Starter Disassembly.
2. Remove screws securing brush holder assembly to end cap (plate). Note orientation for reassembly later. Discard old brush holder assembly.
3. Clean component parts as required.

   New brushes and springs come preassembled in a brush holder with a protective sleeve that will also serve as an installation tool.
4. Perform steps 10-13 in Starter Reassembly sequence. If starter has been disassembled, installation must be done after armature, drive lever, and frame are installed.

Starter Reassembly

NOTE: Always use a new retainer. Do not reuse old retainers that have been removed.

NOTE: Correctly installed, center pivot section of drive lever will be flush or below machined surface of housing.

1. Apply drive lubricant to armature shaft splines. Install drive pinion onto armature shaft.
2. Install and assemble stop collar/retainer assembly.
   a. Install stop collar down onto armature shaft with counter bore (recess) up.
   b. Install a new retainer in larger (rear) groove of armature shaft. Squeeze with a pliers to compress it in groove.
   c. Slide stop collar up and lock it into place, so recess surrounds retainer in groove. If necessary, rotate pinion outward on armature splines against retainer to help seat collar around retainer.
3. Install offset thrust (stop) washer so smaller offset of washer faces retainer/collar.
4. Apply a small amount of oil to bearing in drive end cap, and install armature with drive pinion.
5. Lubricate fork end and center pivot of drive lever with drive lubricant. Position fork end into space between captured washer and rear of pinion.
6. Slide armature into drive end cap and at same time seat drive lever into housing.
7. Install rubber grommet into matching recess of drive end cap. Molded recesses in grommet should be out, matching and aligned with those in end cap.
8. Install frame, with small notch forward, onto armature and drive end cap. Align notch with corresponding section in rubber grommet. Install drain tube in rear cutout, if it was removed previously.
9. Install flat thrust washer onto commutator end of armature shaft.
10. Starter reassembly when replacing brushes/brush holder assembly:
    a. Hold starter assembly vertically on end housing, and carefully position assembled brush holder assembly, with supplied protective tube, against end of commutator/armature. Mounting screw holes in metal clips must be up/out. Slide brush holder assembly down into place around commutator, and install positive (+) brush lead grommet in cutout of frame. Protective tube may be saved and used for future servicing.

    Starter reassembly when not replacing brushes/ brush holder assembly:
    a. Carefully unhook retaining caps from brush assemblies. Do not lose springs.
    b. Position brushes back in their slots so they are flush with I.D. of brush holder assembly. Insert brush installation tool (with extension), or use tube described above from a prior brush installation, through brush holder assembly, so holes in metal mounting clips are up/out.

c. Install brush springs and snap on retainer caps.

d. Hold starter assembly vertically on end housing, and carefully place tool (with extension) and assembled original brush holder assembly onto end of armature shaft. Slide brush holder assembly down into place around commutator, install positive (+) brush lead grommet in cutout of frame.

11. Install end cap onto armature and frame, aligning thin raised rib in end cap with corresponding slot in grommet of positive (+) brush lead.
12. Install thru bolts and brush holder mounting screws. Torque bolts to 5.6-9.0 N·m (49-79 in. lb.) and brush holder mounting screws to 2.5-3.3 N·m (22-29 in. lb.).
13. Hook plunger behind upper end of drive lever and install spring into solenoid. Insert mounting screws through holes in drive end cap. Use these to hold solenoid gasket in position, then mount solenoid. Torque screws to 4.0-6.0 N·m (35-53 in. lb.).
14. Connect positive (+) brush lead/bracket to solenoid and secure with nut. Torque nut to 8-11 N·m (71-97 in. lb.). Do not overtighten.

Solenoid Tests

NOTE: DO NOT leave 12 volt test leads connected to solenoid for any time over what is necessary for performing each of individual tests. Internal damage to solenoid may occur.

Disconnect all leads from solenoid including positive brush lead attached to lower stud terminal. Remove mounting hardware and separate solenoid from starter for testing.

To test solenoid pull-in coil/plunger:

Actuation

1. Use a 12 volt power supply and 2 test leads.
2. Connect 1 lead to flat spade S/start terminal on solenoid. Momentarily connect other lead to lower large post terminal.

   When connection is made solenoid should energize (audible click) and plunger retract. Repeat test several times.

Continuity

1. Use an ohmmeter set to audible or Rx2K scale, and connect 2 ohmmeter leads to 2 large post terminals.
2. Perform solenoid pull-in coil/plunger actuation test and check for continuity. Ohmmeter should indicate continuity. Repeat test several times.

To test solenoid hold-in coil:

Function

1. Connect a 12 volt test lead to flat spade S/start terminal on solenoid and other lead to body or mounting surface of solenoid.
2. Manually push plunger IN and check if coil holds plunger retracted. Do not allow test leads to remain connected to solenoid for a prolonged period of time.

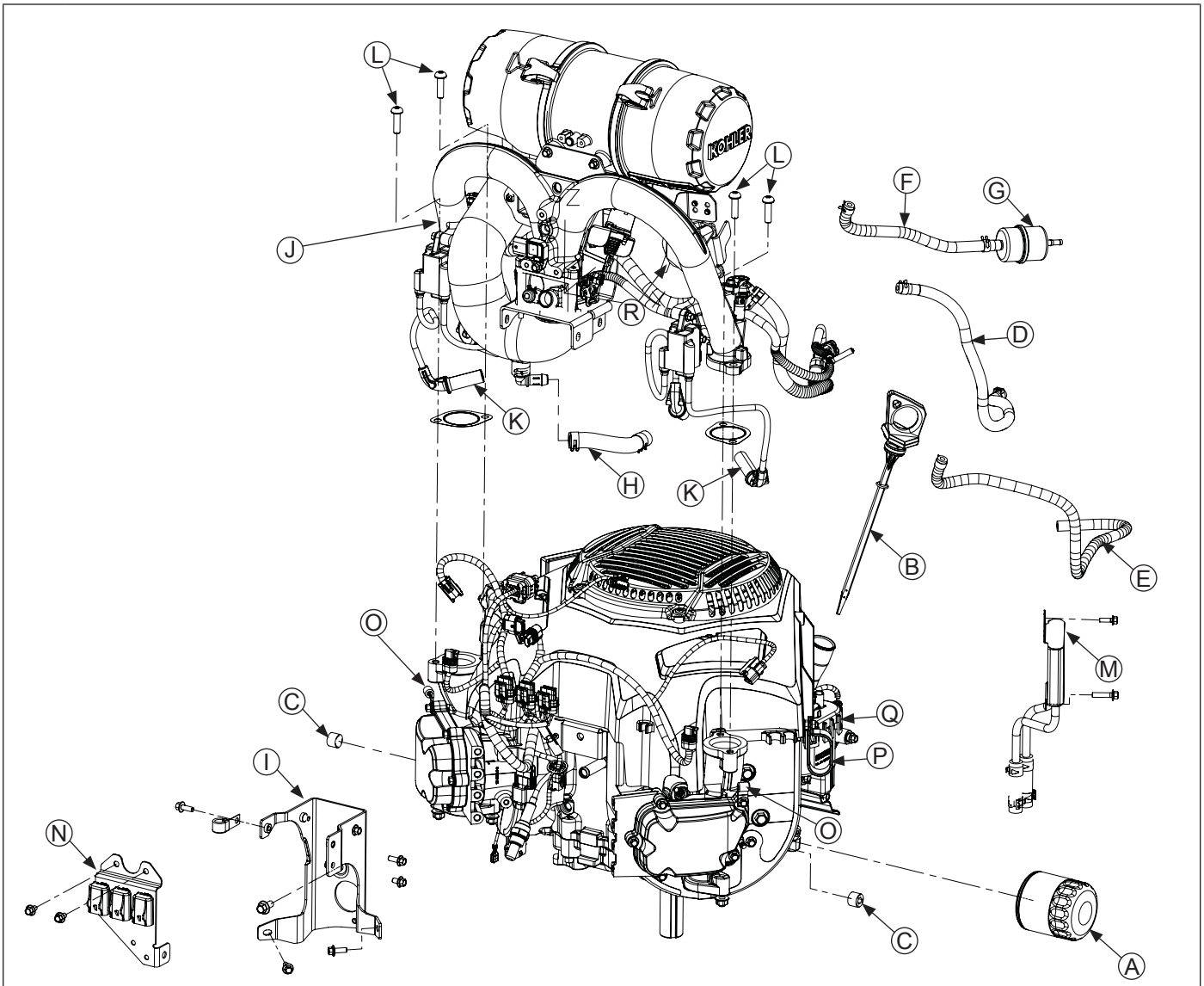
Continuity

1. Use an ohmmeter set to audible or Rx2K scale, and connect 2 ohmmeter leads to 2 large post terminals.
2. Perform preceding solenoid hold-in coil function test and check for continuity. Meter should indicate continuity. Repeat test several times.

Condition	Conclusion
Solenoid fails to activate.	Replace solenoid.
No continuity is indicated.	
Plunger fails to stay retracted.	

	⚠ WARNING	Before working on engine or equipment, disable engine as follows: 1) Disconnect spark plug lead(s). 2) Disconnect negative (–) battery cable from battery.
	Accidental Starts can cause severe injury or death. Disconnect and ground spark plug lead(s) before servicing.	

External Engine Components



A	Oil Filter	**B**	Dipstick	**C**	Oil Drain Plug	**D**	High Pressure Fuel Line
E	Pulse Line	**F**	Low Pressure Fuel Line	**G**	Fuel Filter	**H**	Breather Hose
I	Throttle Body Bracket	**J**	Manifold Assembly	**K**	Spark Plug Lead	**L**	Manifold Screw
M	Oil Cooler	**N**	Fuse Holder Bracket	**O**	J-Clip	**P**	Clamp
Q	Fuel Pump Module (FPM)	**R**	Fuel Pump				

Clean all parts thoroughly as engine is disassembled. Only clean parts can be accurately inspected and gauged for wear or damage. There are many commercially available cleaners that will quickly remove grease, oil and grime from engine parts. When such a cleaner is used, follow manufacturer's instructions and safety precautions carefully.

Make sure all traces of cleaner are removed before engine is reassembled and placed into operation. Even small amounts of these cleaners can quickly break down lubricating properties of engine oil.

NOTE: This disassembly sequence removes some components in subassemblies to enable technician to perform internal engine servicing. Do not disconnect every EFI and electronic governor component.

Disconnect Spark Plug Leads

NOTE: Pull on boot only, to prevent damage to spark plug lead.

1. Disconnect leads from spark plugs and unhook from J-clips on valve covers.
2. Shut off fuel supply.

Drain Oil from Crankcase and Remove Oil Filter

1. Clean oil filter and housing area.
2. Remove dipstick and 1 oil drain plug.
3. Allow ample time for oil to drain from crankcase.
4. Remove and discard oil filter.

Disconnect Fuel Lines

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Do not fill fuel tank while engine is hot or running.

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.

NOTE: To prevent damage to hoses, use a hose removal tool.

1. Wrap a shop towel completely around high pressure fuel line connector and disconnect from Fuel Pump Module (FPM).

   Using a small screwdriver under hose connector, press release button and slowly pull connector away from FPM, allowing shop towel to absorb any residual fuel in high pressure fuel line. Any spilled fuel must be wiped up immediately.
2. Lift locking tab and squeeze to disconnect electrical connector from FPM.
3. Disconnect pulse line and low pressure fuel line (with fuel filter) from impulse pump.
4. Disconnect pulse line from FPM.
5. Remove and slide hoses through clamp mounted on blower housing.
6. Remove clamp from blower housing.

Remove Fuse Cover (Optional)

Remove fasteners securing cover over fuses; remove fuse cover.

Disconnect Wire Harness

1. Disconnect wire harness from all sensors, coils, and injectors.

   Use a small screwdriver to push red safety latch on TMAP sensor to disconnect.
2. If equipped with an electronic governor, disconnect harness from Governor Control Unit (GCU), and Digital Linear Actuator (DLA).

   Use a small screwdriver to unhook harness from GCU.
3. Disconnect fuses from holders in bracket.
4. Remove diagnostic plug from fuse holder bracket.
5. Carefully pull wire harness through manifold assembly and allow harness to hang below throttle body.

Disconnect Breather Hose

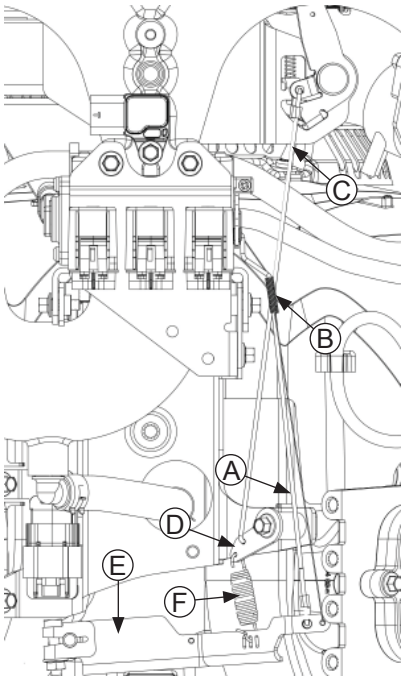
Disconnect breather hose from elbow of large air intake hose.

Remove Throttle Body Bracket

Remove three screws securing throttle body bracket to crankcase.

Remove Governor Linkages, Spring, and Lever (Mechanical Governor)

Mechanical Governor Components



A	Governor Linkage	**B**	Linkage Spring
C	Speed Control Linkage	**D**	Governor Linkage Lever
E	Governor Lever	**F**	Governor Spring

1. Unhook governor linkage and linkage spring from throttle body. Note color, location, and position of each.
2. Disconnect speed control linkage from governor linkage lever. Note color, location, and position.
3. Loosen nut and remove governor lever from cross shaft; note hole location, then unhook governor spring from governor lever.

Remove Manifold Assembly

Remove four manifold screws from cylinder head and carefully lift and remove manifold assembly.

Assembly includes air cleaner, hose, elbow, throttle body, intake manifold, fuel pump, fuel rail assembly, injectors, TMAP sensor, ECU, and brackets. If equipped with electronic governor it also includes GCU and DLA.

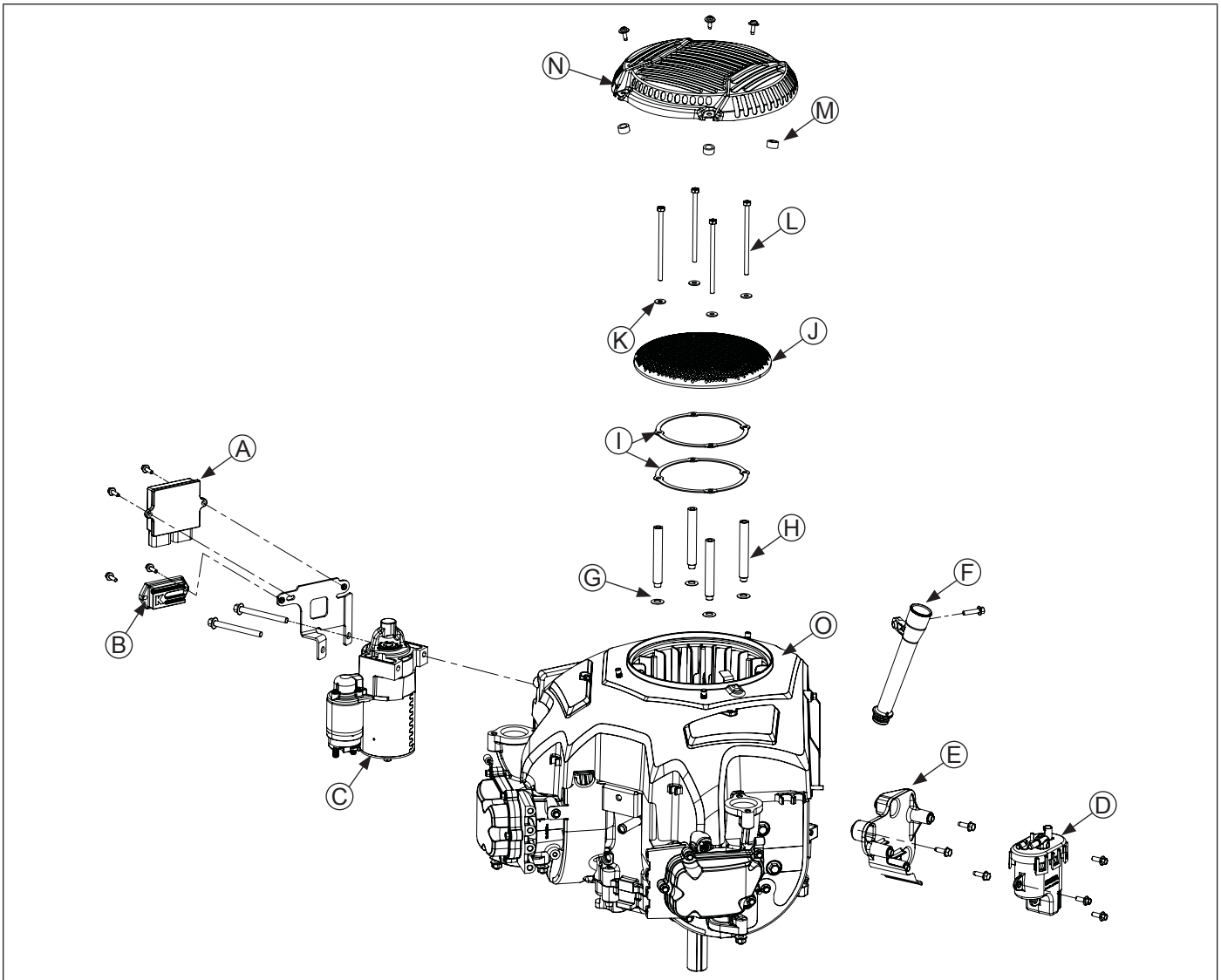
Separate parts only if additional service is required. Refer to pages 86 and 87.

Remove Oil Cooler (if equipped)

NOTE: New clamps are recommended any time disassembly is performed, or if clamps have been loosened (expanded) several times.

1. Remove oil cooler mounting screws. Do not lose any washers (if used).
2. Note orientation of clamps before disassembling for proper clearance during reassembly. Loosen clamps and disconnect hoses from oil pan.

Blower Housing/Starter Motor/Fuel Pump Module Components



A	ECU	**B**	Rectifier-Regulator	**C**	Starter Motor Assembly	**D**	Fuel Pump Module
E	Fuel Pump Module Baffle	**F**	Oil Fill Tube	**G**	Washer	**H**	Spacer
I	Support Rings	**J**	Debris Screen	**K**	Washer	**L**	Screw
M	Spacer	**N**	Fixed Guard	**O**	Blower Housing		

Remove Fuel Pump Module (FPM)

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

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Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.

1. Remove 3 screws securing FPM to baffle and remove FPM.
2. Remove 3 screws securing baffle to crankcase and remove baffle.

Remove Starter Motor

1. Disconnect leads from starter.
2. Remove screws and starter.

Remove Fixed Guard

Remove screws securing fixed guard and spacers; remove guard and spacers.

Remove Debris Screen

NOTE: Fan will be loose, but cannot be removed until after blower housing is removed.

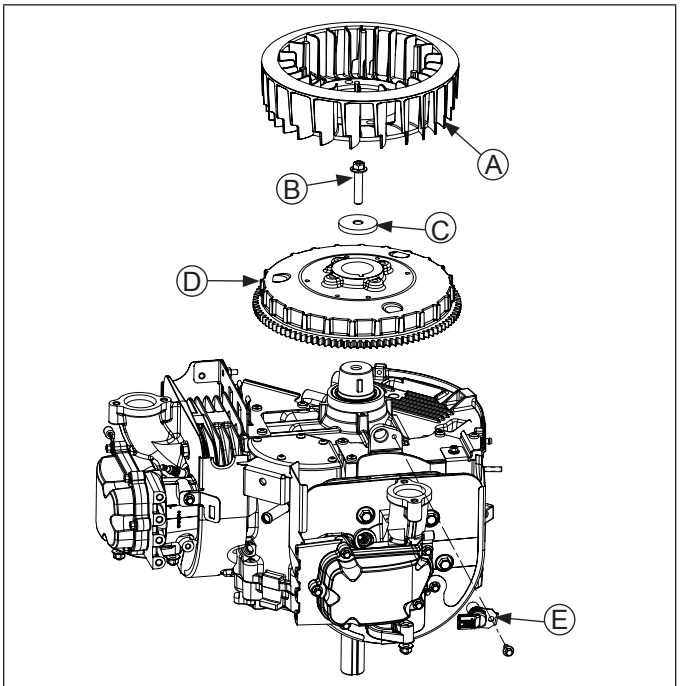
1. Remove screws securing screen and remove screen.
2. Remove spacers, paying attention to curvature of spring washers between spacers and fan.
3. Remove mounting screw and oil fill tube.

Remove Blower Housing

1. Unplug wire harness from ECU and rectifier-regulator. ECU and rectifier-regulator do not need to be removed from blower housing.
2. Loosen screws and nuts securing blower housing to crankcase.
3. Remove blower housing.

Remove Flywheel Assembly

Flywheel/Fan Components



A	Flywheel Fan	**B**	Flywheel Screw
C	Washer	**D**	Flywheel
E	Crankshaft Position Sensor		

NOTE: Always use a flywheel strap wrench or holding tool to hold flywheel when loosening or tightening flywheel screw. Do not use any type of bar or wedge to hold flywheel. Use of such tools could cause flywheel to become cracked or damaged.

NOTE: Always use a flywheel puller to remove flywheel from crankshaft. Do not strike crankshaft or flywheel, as these parts could become cracked or damaged.

1. Remove fan from flywheel.
2. Use a flywheel strap wrench or holding tool to hold flywheel and loosen screw securing flywheel to crankshaft.
3. Remove screw and washer.
4. Use a puller to remove flywheel from crankshaft.
5. Remove woodruff key from crankshaft.

Inspection

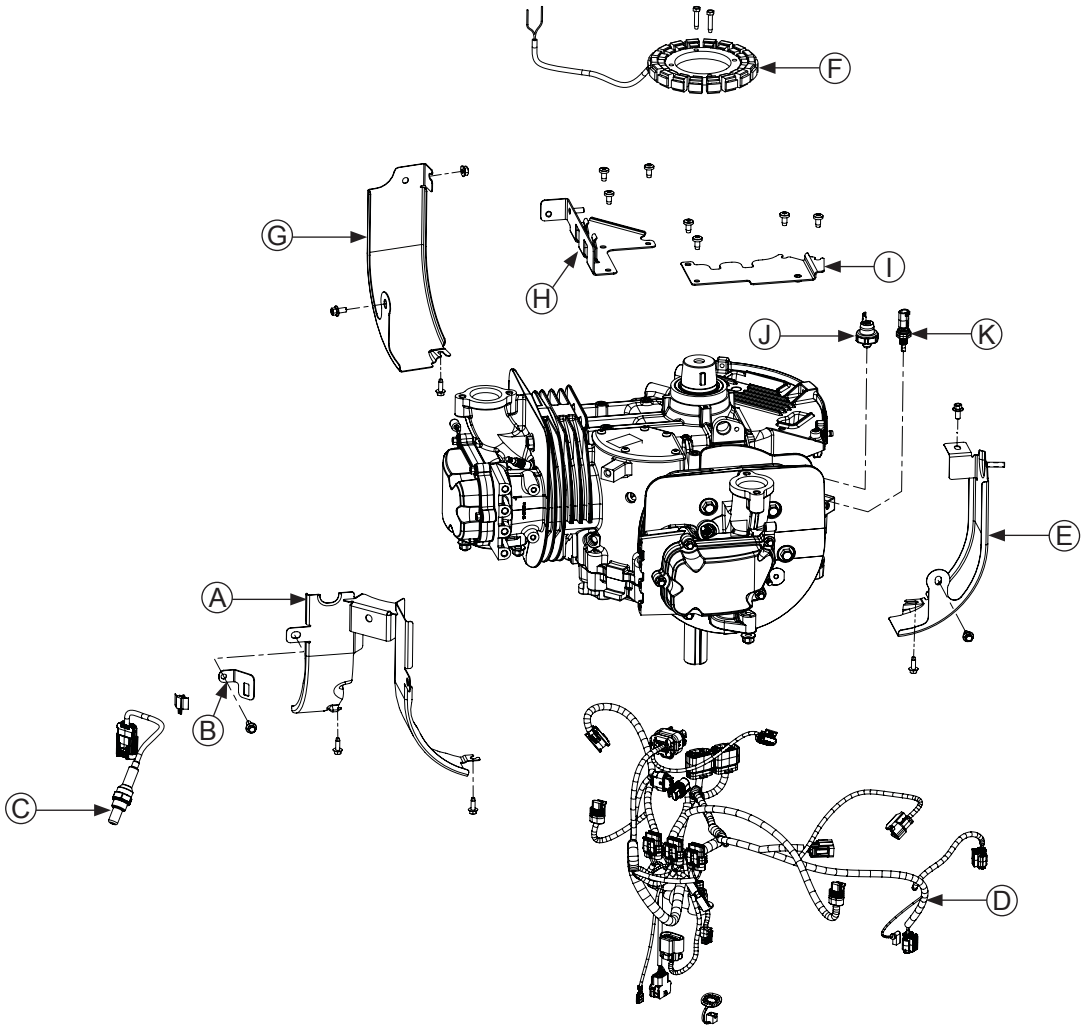
Inspect flywheel for cracks and flywheel keyway for damage. Replace flywheel if it is cracked. Replace flywheel, crankshaft, and key if flywheel key is sheared or keyway is damaged.

Inspect ring gear for cracks or damage. Kohler does not provide ring gear as a serviceable part. Replace flywheel if ring gear is damaged.

Remove Crankshaft Position Sensor

Remove crankshaft position sensor with harness attached.

Remove Baffles/Wire Harness/Stator Components



A	Valley Baffle	**B**	Mounting Bracket	**C**	O2 Sensor	**D**	Wire Harness
E	Cylinder #2 Baffle	**F**	Stator	**G**	Cylinder #1 Baffle	**H**	Crankcase Baffle #1
I	Crankcase Baffle #2	**J**	Oil Sentry™ Pressure Switch	**K**	Oil Temperature Sensor		

Remove Valley Baffle

Remove two lower screws on PTO side and remove screw in valley area that includes O2 sensor mounting bracket. Remove valley baffle.

Remove Cylinder Baffles

Remove screws and cylinder baffles.

Remove Crankcase Baffles

Remove screws and crankcase baffles.

Remove Stator

Remove screws and stator. Wire harness may stay connected to stator.

Remove Ground Wire and Wire Harness

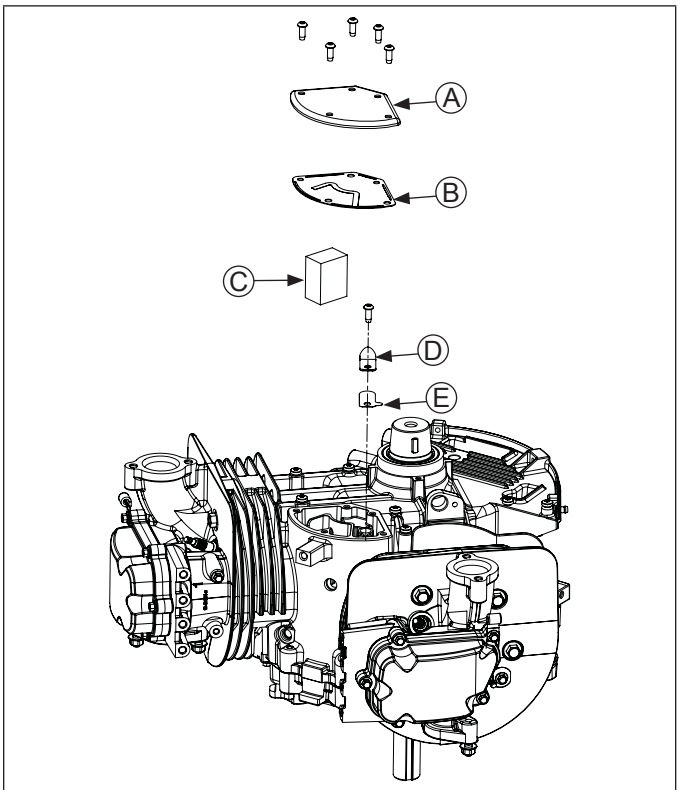
1. Remove wire harness ground on #1 crankcase baffle.
2. Disconnect oil temperature sensor connector and Oil Sentry™ pressure switch lead.

   Remove Oil Sentry™ pressure switch from oil pan only if replacing.

   Remove oil temperature sensor from oil pan only if replacing.
3. Remove wire harness from engine with stator attached.

Remove Breather Assembly

Breather Assembly Components

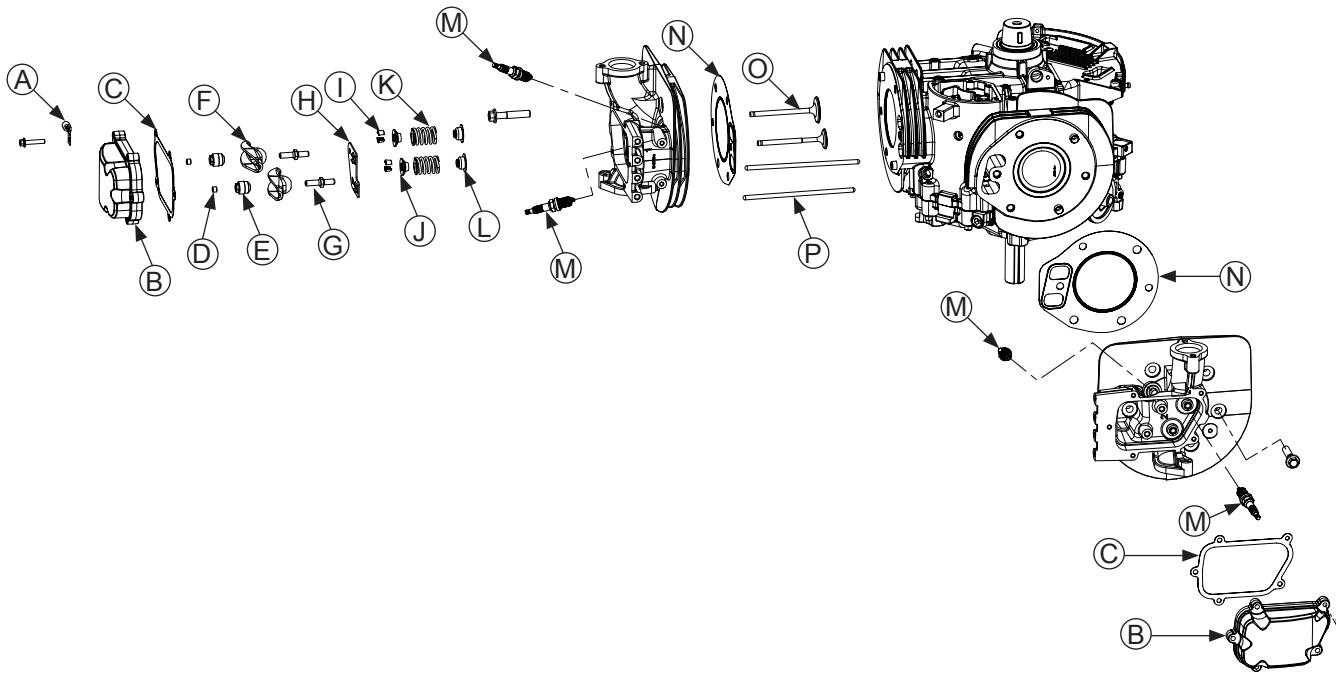


A	Breather Cover	**B**	Gasket
C	Filter	**D**	Reed Retainer
E	Reed		

NOTE: All breather components can be accessed without opening crankcase.

1. Remove fasteners securing breather cover to crankcase.
2. Carefully break gasket seal and remove cover, gasket, and filter. Do not pry on sealing surfaces as it could cause damage resulting in leaks. Note assembly and orientation of parts.
3. Remove screw, reed retainer, and reed.

Cylinder Head Components



A	J-Clip	**B**	Valve Cover	**C**	Gasket	**D**	Set Screw
E	Rocker Arm Pivot	**F**	Rocker Arm	**G**	Rocker Arm Stud	**H**	Push Rod Guide Plate
I	Valve Spring Keepers	**J**	Valve Spring Cap	**K**	Valve Spring	**L**	Valve Stem Seal
M	Spark Plug	**N**	Head Gasket	**O**	Valve	**P**	Push Rod

Remove Valve Covers

1. Remove screw securing each valve cover. Note location of J-Clip on each valve cover for reassembly.
2. Remove valve cover and gasket from each cylinder head. Note valve cover differences for proper location in reassembly.

Remove Spark Plugs

Remove both spark plugs from each cylinder head.

Remove Cylinder Heads

NOTE: Cylinder head number is embossed on outside of each cylinder head.

1. Loosen set screws and rocker arm pivots for each rocker arm enough to remove push rods.
2. Mark position of push rods as either intake or exhaust and cylinder #1 or #2. Push rods should always be reinstalled in same positions.
3. Remove screws securing cylinder head.
4. Carefully remove cylinder head and head gasket.
5. Repeat procedure for other cylinder head.

Disassemble Cylinder Heads

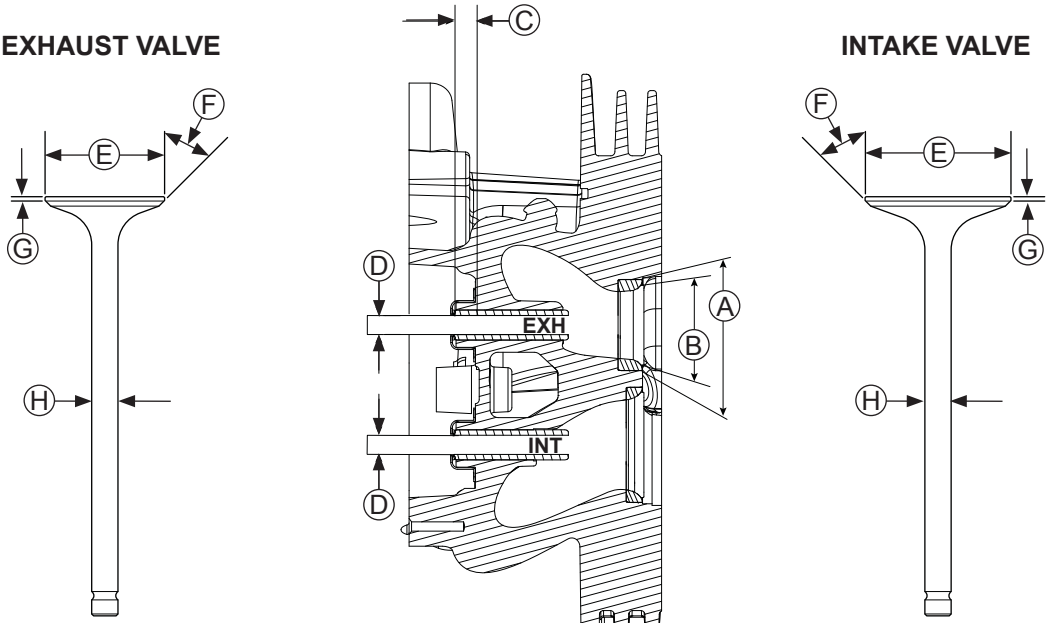
NOTE: These engines use valve stem seals on intake and exhaust valves. Use a new seal whenever valves are removed, or if seal is deteriorated in any way. Never reuse an old seal.

1. Remove set screws, rocker arm pivots, rocker arms, and push rods from cylinder head. Remove pivot studs and guide plate as required.
2. Compress valve springs using a valve spring compressor.

3. Once valve spring is compressed, remove following items:
   - Valve spring keepers.
   - Valve springs.
   - Valve spring caps.
   - Intake and exhaust valves (mark position).
   - Valve stem seals.

4. Repeat above procedure for other cylinder head. Do not interchange parts from one cylinder head to another.

Inspection and Service
Valve Details



	Dimension	Intake	Exhaust
A	Seat Angle	89°	89°
B	Seat Taper	30°	30°
C	Guide Depth	7.65/8.05 mm (0.3012/0.3169 in.)	7.65/8.05 mm (0.3012/0.3169 in.)
D	Guide I.D.	7.038/7.058 mm (0.2771/0.2779 in.)	7.038/7.058 mm (0.2771/0.2779 in.)
E	Valve Head Diameter	38.600/38.805 mm (1.5197/1.5295 in.)	29.375/29.625 mm (1.1565/1.1663 in.)
F	Valve Face Angle	45°	45°
G	Valve Margin (Min.)	1.0 mm (0.0393 in.)	1.0 mm (0.0393 in.)
H	Valve Stem Diameter	6.982/7.000 mm (0.2749/0.2756 in.)	6.970/6.988 mm (0.2744/0.2751 in.)

After cleaning, check flatness of cylinder head and corresponding top surface of crankcase using a surface plate or piece of glass and feeler gauge. Maximum allowable out of flatness is 0.08 mm (0.0031 in.).

Carefully inspect valve mechanism parts. Inspect valve springs and related hardware for excessive wear or distortion. Check valves and valve seat area or inserts for evidence of deep pitting, cracks, or distortion. Check clearance of valve stems in guides.

Hard starting or loss of power accompanied by high fuel consumption may be symptoms of faulty valves. Although these symptoms could also be attributed to worn rings, remove and check valves first. After removal, clean valve heads, faces, and stems with a power wire brush.

Then, carefully inspect each valve for defects such as a warped head, excessive corrosion, or a worn stem end. Replace valves found to be in bad condition.

Valve Guides
If a valve guide is worn beyond specifications, it will not guide valve in a straight line. This may result in burnt valve faces or seats, loss of compression, and excessive oil consumption.

To check valve guide-to-valve stem clearance, thoroughly clean valve guide and, using a split-ball gauge, measure inside diameter of guide. Then, using an outside micrometer, measure diameter of valve stem at several points on stem where it moves in valve guide. Use largest stem diameter to calculate clearance by subtracting stem diameter from guide diameter. If intake clearance exceeds 0.038/0.076 mm (0.0015/0.0030 in.) or exhaust clearance exceeds 0.050/0.088 mm (0.0020/0.0035 in.), determine if valve stem or guide is responsible for excessive clearance.

Maximum (I.D.) wear on intake valve guide is 7.132 mm (0.2808 in.) and 7.157 mm (0.2818 in.) for exhaust guide. Guides are not removable but can be reamed 0.25 mm (0.010 in.) oversize. Valves with 0.25 mm oversize stems must then be used.

If guides are within limits but valve stems are worn beyond limits, install new valves.

Valve Seat Inserts
Hardened steel alloy intake and exhaust valve seat inserts are press fitted into cylinder head. Inserts are not replaceable but can be reconditioned if not too badly pitted or distorted. If cracked or badly warped, cylinder head should be replaced.

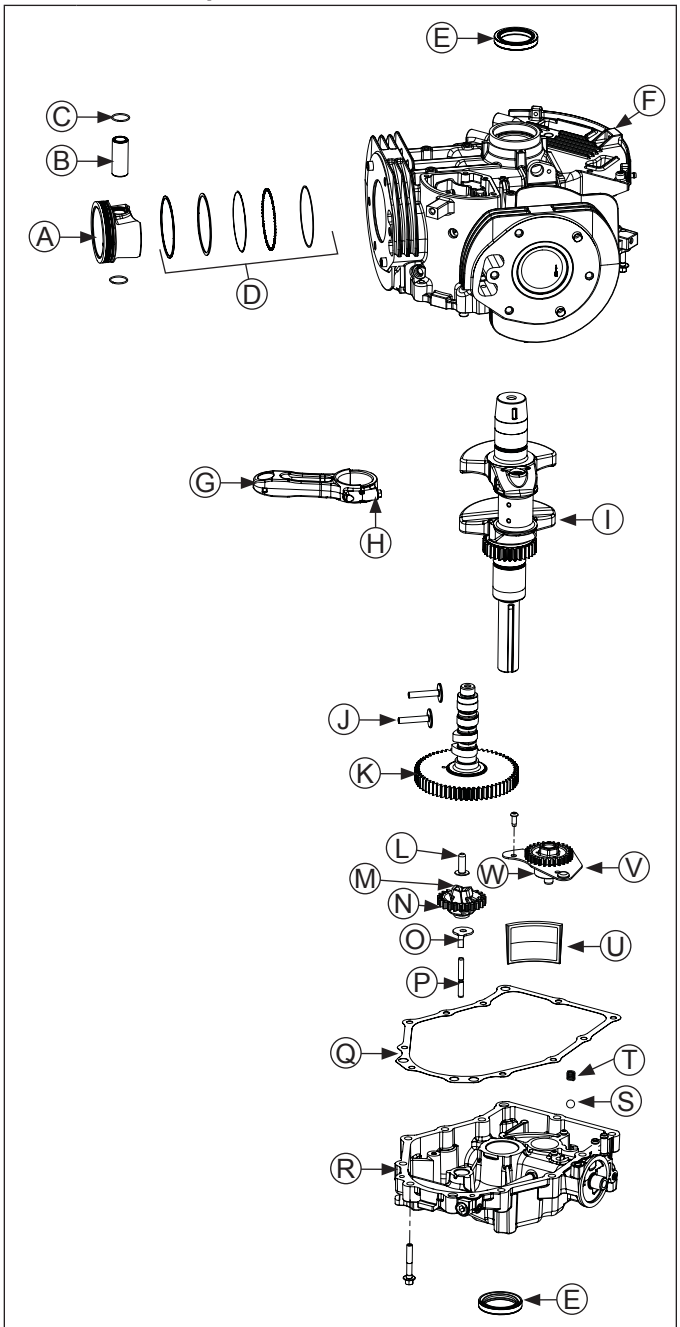
Recondition valve seat inserts following instructions provided with valve seat cutter being used. Final cut should be made with an 89° cutter as specified for valve seat angle. Cutting proper 45° valve face angle as specified, and proper valve seat angle (44.5°, half of full 89° angle), will achieve desired 0.5° (1.0° full cut) interference angle where maximum pressure occurs on outside diameters of valve face and seat.

Lapping Valves
NOTE: Exhaust valves that are black in color cannot be ground and do not require lapping.

Reground or new valves must be lapped in, to provide proper fit. Use a hand valve grinder with a suction cup for final lapping. Lightly coat valve face with a fine grade of grinding compound, then rotate valve on its seat with grinder. Continue grinding until a smooth surface is obtained on seat and on valve face. Thoroughly clean cylinder head in soap and hot water to remove all traces of grinding compound. After drying cylinder head, apply a light coating of SAE 10 oil to prevent rusting.

Valve Stem Seals
These engines use valve stem seals on intake and exhaust valves. Always use new seals when valves are removed from cylinder head. Seals should also be replaced if deteriorated or damaged in any way. Never reuse an old seal.

Crankcase Components



A	Piston	**B**	Piston Pin
C	Piston Pin Retainer Clip	**D**	Piston Rings
E	Oil Seal	**F**	Crankcase
G	Connecting Rod	**H**	Connecting Rod End Cap
I	Crankshaft	**J**	Tappet
K	Camshaft	**L**	Regulating Pin*
M	Flyweight*	**N**	Governor Gear*
O	Locking Tab Thrust Washer*	**P**	Governor Gear Shaft*

Q	Gasket	**R**	Oil Pan
S	Relief Ball	**T**	Spring
U	Oil Screen	**V**	Oil Pump
W	Geroter Gear		

*Mechanical Governor only.

Remove Oil Pan Assembly

1. Remove screws securing oil pan to crankcase.
2. Locate protruding tabs on oil pan. Carefully tap to break gasket seal. Do not pry on sealing surfaces as this could cause leaks. Separate oil pan from crankcase. Remove old gasket.

Inspection
Inspect oil seal in oil pan and remove it if it is worn or damaged.

Inspect crankshaft bearing surface for wear or damage (refer to Specifications). Replace oil pan assembly if required.

Oil Pump Assembly

Oil pump is mounted inside oil pan. If service is required, continue with Disassembly, Inspection, and Reassembly.

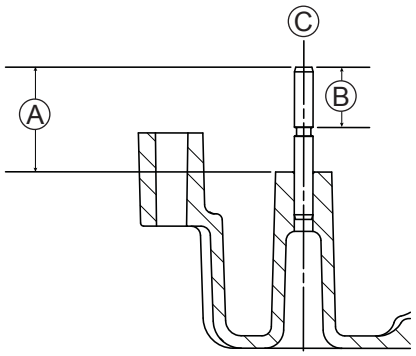
Disassembly
1. Remove screws securing oil pump housing.
2. Lift oil pump assembly from oil pan. Remove outer geroter gear and pickup screen from oil pan.
3. Ensure ball and spring remain installed in pressure relief hole of oil pan. If ball and spring fall out of pressure relief hole, see reassembly for correct installation.

Inspection
Inspect oil pump housing, gear, and rotors for nicks, burrs, wear, or any visible damage. If any parts are worn or damaged, replace oil pump assembly. Check oil pickup screen for damage or restriction, replace if necessary.

Reassembly
1. Lubricate outer gerotor gear with oil. Install outer gerotor gear through shaft of oil pump, around inner gerotor gear. Matching molding dots on inner and outer gerotor gears is not necessary and will not affect oil pump efficiency.
2. Reinstall ball, then spring into pressure relief hole in oil pan.
3. Install oil pump inserting center shaft into corresponding recess in oil pan. Apply consistent downward pressure to oil pump cover, compressing oil pressure relief spring and start screws. Secure oil pump by torquing screws (in no specific sequence) to 11.3 N·m (100 in. lb.) into new holes, or 7.8 N·m (69 in. lb.) into used holes.
4. After torquing, rotate gear and check for freedom of movement. Make sure there is no binding. If binding occurs, loosen screws, reposition pump, retorque screws and recheck movement.

Governor Gear Assembly (Mechanical Governor)

Governor Shaft Press Depth Detail



A	34.0 mm (1.3386 in.) 33.5 mm (1.3189 in.)	**B**	19.40 mm (0.7638 in.)
C	Gear Shaft		

Governor gear assembly is located inside oil pan. If service is required, continue with Inspection, Disassembly, and Reassembly.

Inspection
Inspect governor gear teeth. Replace gear if it is worn, chipped, or if any teeth are missing. Inspect governor weights. They should move freely in governor gear.

Disassembly
NOTE: Governor gear is held onto shaft by small molded tabs in gear. When gear is removed from shaft, these tabs are destroyed and gear must be replaced. Therefore, remove gear only if absolutely necessary.

Governor gear must be replaced once it is removed from oil pan.

1. Use 2 small screwdrivers and carefully pry upward to unseat governor gear assembly from governor gear shaft. Remove regulating pin and governor gear assembly.
2. Remove locking tab thrust washer and note orientation.
3. Carefully inspect governor gear shaft and replace it only if it is damaged. After removing damaged shaft, press or lightly tap replacement shaft into oil pan to depth shown.

Reassembly
1. Install locking tab thrust washer on governor gear shaft with tab down.
2. Position regulating pin within governor gear/ flyweights assembly and slide both onto governor shaft until assembly locks into place.

Remove Camshaft and Valve Tappets

1. Remove camshaft and shim (if used).
2. Remove valve tappets from crankcase and mark them by their location, as either intake or exhaust and cylinder 1 or 2. Tappets should always be reinstalled in same position.

Camshaft Inspection and Service
Check lobes of camshaft for wear or damage. Inspect cam gear for badly worn, chipped, or missing teeth. Replacement of camshaft will be necessary if any of these conditions exist.

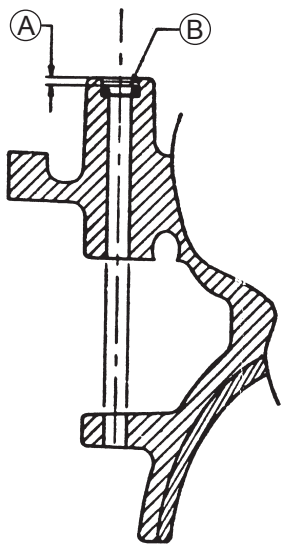
Valve Tappet Inspection
Check base surface of valve tappet(s) for wear or damage. Replace tappets(s) if condition is questionable in any way. Corresponding camshaft lobe(s) should also be checked for wear or damage. Whenever tappets are replaced, apply a liberal coating of Kohler lubricant to base of each new tappet before it is installed.

Remove Governor Cross Shaft (Mechanical Governor)

1. Remove retainer and nylon washer, from governor cross shaft.
2. Remove cross shaft through inside of crankcase.

Governor Cross Shaft Oil Seal (Mechanical Governor)

Cross Shaft Oil Seal Details



A	2.0 mm (0.0787 in.)
B	Governor Cross Shaft Seal

If governor cross shaft seal is damaged and/or leaks, replace it using these following procedures.

Remove oil seal from crankcase and replace it with a new one. Install new seal to depth shown using a seal installer.

Remove Connecting Rods with Pistons and Rings

NOTE: If a carbon ridge is present at top of either cylinder bore, use a ridge reamer tool to remove ridge before attempting to remove piston.

NOTE: Cylinders are numbered on crankcase. Use numbers to mark each end cap, connecting rod and piston for reassembly. Do not mix end caps and connecting rods.

1. Remove screws securing closest connecting rod end cap. Remove end cap.
2. Carefully remove connecting rod and piston assembly from cylinder bore.
3. Repeat above procedures for other connecting rod and piston assembly.

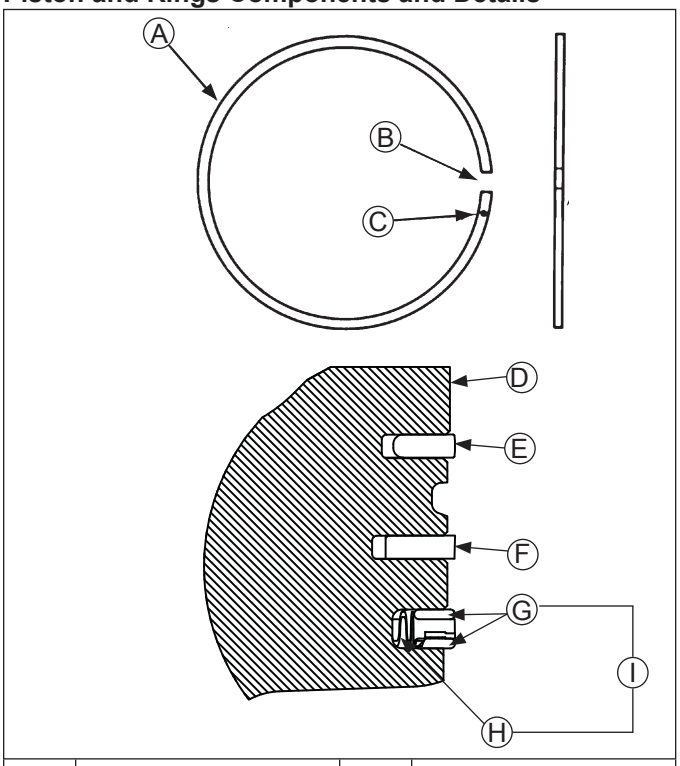
Connecting Rods
Offset, stepped-cap connecting rods are used in these engines.

Inspection and Service
Check bearing area (big end) for excessive wear, score marks, running and side clearances. Replace rod and cap if scored or excessively worn.

Service replacement connecting rods are available in STD crankpin size and 0.25 mm (0.010 in.) undersize. Always refer to appropriate parts information to ensure that correct replacements are used.

Piston and Rings

Inspection and Service
Piston and Rings Components and Details



A	Piston Ring	**B**	End Gap
C	Identification Mark	**D**	Piston
E	Top Compression Ring	**F**	Center Compression Ring
G	Rails	**H**	Expander
I	Oil Control Ring (3 Piece)		

Scuffing and scoring of pistons and cylinder walls occurs when internal engine temperatures approach welding point of piston. Temperatures high enough to do this are created by friction, which is usually attributed to improper lubrication and/or overheating of engine.

Normally, very little wear takes place in piston boss-piston pin area. If original piston and connecting rod can be reused after new rings are installed, original pin can also be reused but new piston pin retainers are required. Piston pin is included as part of piston assembly – if pin boss in piston or pin are worn or damaged, a new piston assembly is required.

Ring failure is usually indicated by excessive oil consumption and blue exhaust smoke. When rings fail, oil is allowed to enter combustion chamber where it is burned along with fuel. High oil consumption can also occur when piston ring end gap is incorrect because ring cannot properly conform to cylinder wall under this condition. Oil control is also lost when ring gaps are not staggered during installation.

When cylinder temperatures get too high, lacquer and varnish collect on pistons causing rings to stick, which results in rapid wear. A worn ring usually takes on a shiny or bright appearance.

Scratches on rings and pistons are caused by abrasive material such as carbon, dirt, or pieces of hard metal.

Detonation damage occurs when a portion of fuel charge ignites spontaneously from heat and pressure shortly after ignition. This creates 2 flame fronts which meet and explode to create extreme hammering pressures on a specific area of piston. Detonation generally occurs from using low octane fuels.

Preignition or ignition of fuel charge before timed spark can cause damage similar to detonation. Preignition damage is often more severe than detonation damage. Preignition is caused by a hot spot in combustion chamber from sources such as glowing carbon deposits, blocked cooling fins, an improperly seated valve, or wrong spark plug(s).

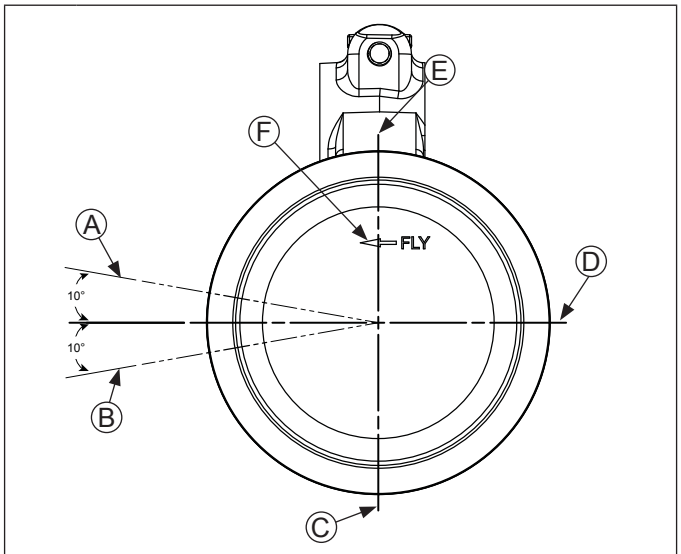
Replacement pistons are available in STD bore size, and in 0.25 mm (0.010 in.), and 0.50 mm (0.020 in.) oversize. Replacement pistons include new piston ring sets and new piston pins.

Replacement ring sets are also available separately for STD, 0.25 mm (0.010 in.), and 0.50 mm (0.020 in.) oversize pistons. Always use new piston rings when installing pistons. Never reuse old rings.

Some important points to remember when servicing piston rings:

1. Cylinder bore must be deglazed before service ring sets are used.
2. If cylinder bore does not need reboring and if old piston is within wear limits and free of score or scuff marks, old piston may be reused.
3. Remove old rings and clean up grooves. Never reuse old rings.
4. Before installing new rings on piston, place top 2 rings, each in turn, in its running area in cylinder bore and check end gap. Compare ring gap to tolerance listed in Specifications.
5. After installing new compression (top and middle) rings on piston, check piston-to-ring side clearance. Compare clearance to tolerance listed in Specifications. If side clearance is greater than specified, a new piston must be used.

Install New Piston Rings
Piston Ring Orientation



A	Top Oil Ring Rail Gap	**B**	Bottom Oil Ring Rail Gap
C	Intermediate Ring Gap	**D**	Oil Ring Expander Gap
E	Top Ring Gap	**F**	FLY Stamp

NOTE: Rings must be installed correctly. Ring installation instructions are usually included with new ring sets. Follow instructions carefully. Use a piston ring expander to install rings. Install bottom (oil control) ring first and top compression ring last.

To install new piston rings, proceed as follows:

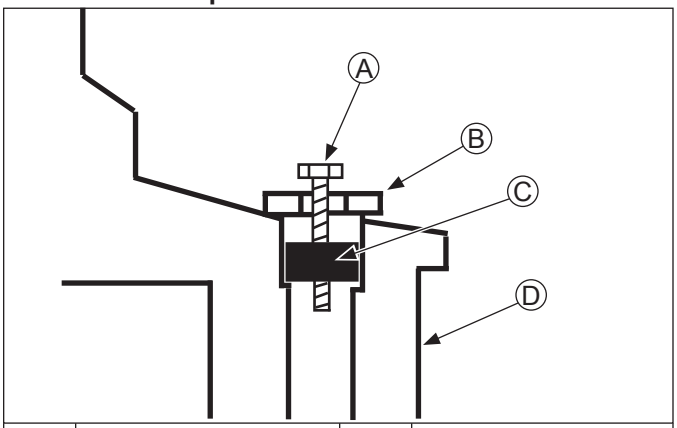
1. Oil control ring (bottom groove): Install expander and then rails. Make sure ends of expander are not overlapped.
2. Middle compression ring (center groove): Install center ring using a piston ring installation tool. Make sure identification mark is up or colored dye stripe (if contained), is to left of end gap.
3. Top compression ring (top groove): Install top ring using a piston ring expander. Make sure identification mark is up or colored dye stripe (if contained), is to left of end gap.

Remove Crankshaft

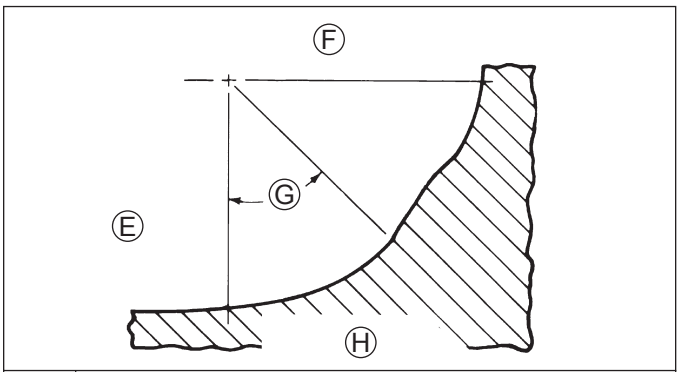
NOTE: If crankpin is reground, visually check to ensure that fillet blends smoothly with crankpin surface.

Carefully pull crankshaft from crankcase. Note thrust washers and shims if used.

Inspection and Service
Crankshaft Components and Details



A	Self-Tapping Screw	**B**	Flat Washer
C	Plug	**D**	Crankshaft



E	Fillet Must Blend Smoothly with Bearing Journal Surface
F	High Point from Fillet Intersections
G	45° Minimum
H	This Fillet Area Must Be Completely Smooth

Inspect gear teeth of crankshaft. If teeth are badly worn, chipped, or some are missing, replacement of crankshaft will be necessary.

Inspect crankshaft bearing surfaces for scoring, grooving, etc. Measure running clearance between crankshaft journals and their respective bearing bores. Use an inside micrometer or telescoping gauge to measure inside diameter of both bearing bores in vertical and horizontal planes. Use an outside micrometer to measure outside diameter of crankshaft main bearing journals. Subtract journal diameters from their respective bore diameters to get running clearances. Check results against values in Specifications. If running clearances are within specification, and there is no evidence of scoring, grooving, etc., no further reconditioning is necessary. If bearing surfaces are worn or damaged, crankcase and/or oil pan will need to be replaced.

Inspect crankshaft keyways. If they are worn or chipped, replacement of crankshaft will be necessary.

Inspect crankpin for score marks or metallic pickup. Slight score marks can be cleaned with crocus cloth soaked in oil. If wear limits, as stated in Clearance Specifications, are exceeded, it will be necessary to replace crankshaft or regrind crankpin to 0.25 mm (0.010 in.) undersize. If reground, a 0.25 mm (0.010 in.) undersize connecting rod (big end) must then be used to achieve proper running clearance. Measure crankpin for size, taper, and out-of-round.

Clearance Specifications-Connecting Rod Journal

O.D. - New	53.00/53.15 mm (2.0866/2.0925 in.)
O.D. - Max. Wear Limit	52.991 mm (2.0862 in.)
Max. Taper	0.018 mm (0.0007 in.)
Max. Out-of-Round	0.025 mm (0.0010 in.)
Width	53.000/53.150 mm (2.0866/2.0925 in.)

Connecting rod journal can be ground 1 size under. When grinding a crankshaft, grinding stone deposits can get caught in oil passages, which could cause severe engine damage. Removing crankpin plug when crankshaft is ground provides easy access for removing any grinding deposits that may collect in oil passages.

Use following procedure to remove and replace plug.

Remove Crankshaft Plug

1. Drill a 3/16 in. hole through plug in crankshaft.
2. Thread a 3/4 in. or 1 in. long self-tapping screw with a flat washer into drilled hole. Flat washer must be large enough to seat against shoulder of plug bore.
3. Tighten self-tapping screw until it draws plug out of crankshaft.

Install New Crankshaft Plug

Use 1 single cylinder camshaft pin, as a driver and tap plug into plug bore until it seats at bottom of bore. Make sure plug is tapped in evenly to prevent leakage.

Remove Flywheel End Oil Seal

Remove oil seal from crankcase using a seal puller.

Crankcase

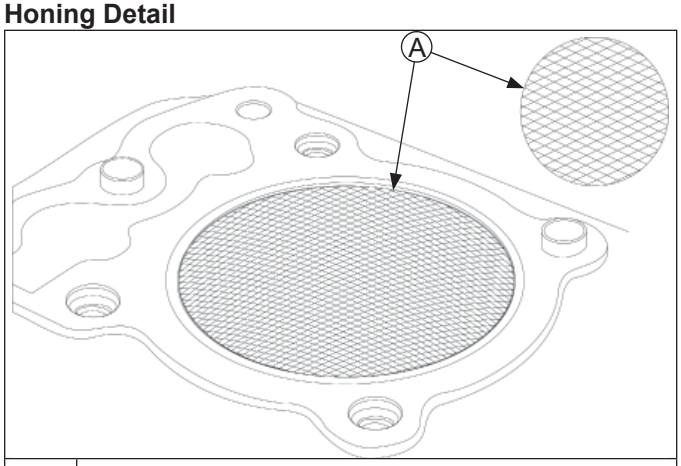
Inspection and Service

Check all gasket surfaces to make sure they are free of gasket fragments. Gasket surfaces must also be free of deep scratches or nicks.

Check cylinder bore for scoring. In severe cases, unburned fuel can cause scuffing and scoring of cylinder wall. It washes necessary lubricating oils off piston and cylinder wall. As raw fuel seeps down cylinder wall, piston rings make metal to metal contact with wall. Scoring of cylinder wall can also be caused by localized hot spots resulting from blocked cooling fins or from inadequate or contaminated lubrication.

If cylinder bore is badly scored, excessively worn, tapered, or out-of-round, resizing is necessary. Use an inside micrometer to determine amount of wear, then select nearest suitable oversize of either 0.25 mm (0.010 in.) or 0.50 mm (0.020 in.). Resizing to these oversizes will allow usage of available oversize piston and ring assemblies. Initially, resize using a boring bar, then use following procedures for honing cylinder.

Honing Detail



A	23°-33° Crosshatch

NOTE: Kohler pistons are custom-machined to exacting tolerances. When oversizing a cylinder, it should be machined exactly 0.25 mm (0.010 in.) or 0.50 mm (0.020 in.) over new diameter. corresponding oversize Kohler replacement piston will then fit correctly.

While most commercially available cylinder hones can be used with either portable drills or drill presses, use of a low speed drill press is preferred as it facilitates more accurate alignment of bore in relation to crankshaft crossbore. Honing is best accomplished at a drill speed of about 250 RPM and 60 strokes per minute. After installing coarse stones in hone, proceed as follows:

1. Lower hone into bore and after centering, adjust so stones are in contact with cylinder wall. Use of a commercial cutting-cooling agent is recommended.
2. With lower edge of each stone positioned even with lowest edge of bore, start drill and honing process. Move hone up and down while resizing to prevent formation of cutting ridges. Check size frequently.
3. When bore is within 0.064 mm (0.0025 in.) of desired size, remove coarse stones and replace them with burnishing stones. Continue with burnishing stones until bore is within 0.013 mm (0.0005 in.) of desired size and then use finish stones (220-280 grit) and polish bore to its final size. A crosshatch should be observed if honing is done correctly. Crosshatch should intersect at approximately 23°-33° off horizontal. Too flat an angle could cause rings to skip and wear excessively, and too steep an angle will result in high oil consumption.

4. After resizing, check bore for roundness, taper, and size. Use an inside micrometer, telescoping gauge, or bore gauge to take measurements. These measurements should be taken at 3 locations in cylinder – at top, middle, and bottom. There are 2 measurements that should be taken (perpendicular to each other) at all 3 locations.

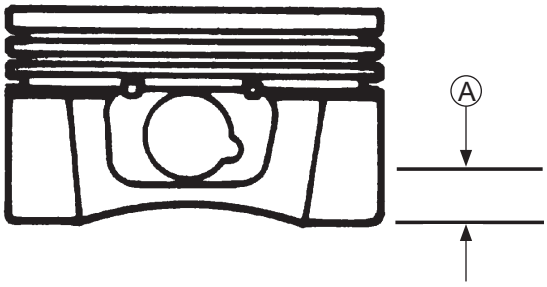
Clean Cylinder Bore After Honing

Proper cleaning of cylinder walls following boring and/or honing is very critical to a successful overhaul. Machining grit left in cylinder bore can destroy an engine in less than 1 hour of operation after a rebuild.

Final cleaning operation should always be a thorough scrubbing with a brush and hot, soapy water. Use a strong detergent that is capable of breaking down machining oil while maintaining a good level of suds. If suds break down during cleaning, discard dirty water and start again with more hot water and detergent. Following scrubbing, rinse cylinder with very hot, clear water, dry it completely, and apply a light coating of engine oil to prevent rusting.

Measuring Piston-to-Bore Clearance

Piston Detail



A	11 mm (0.4331 in.)

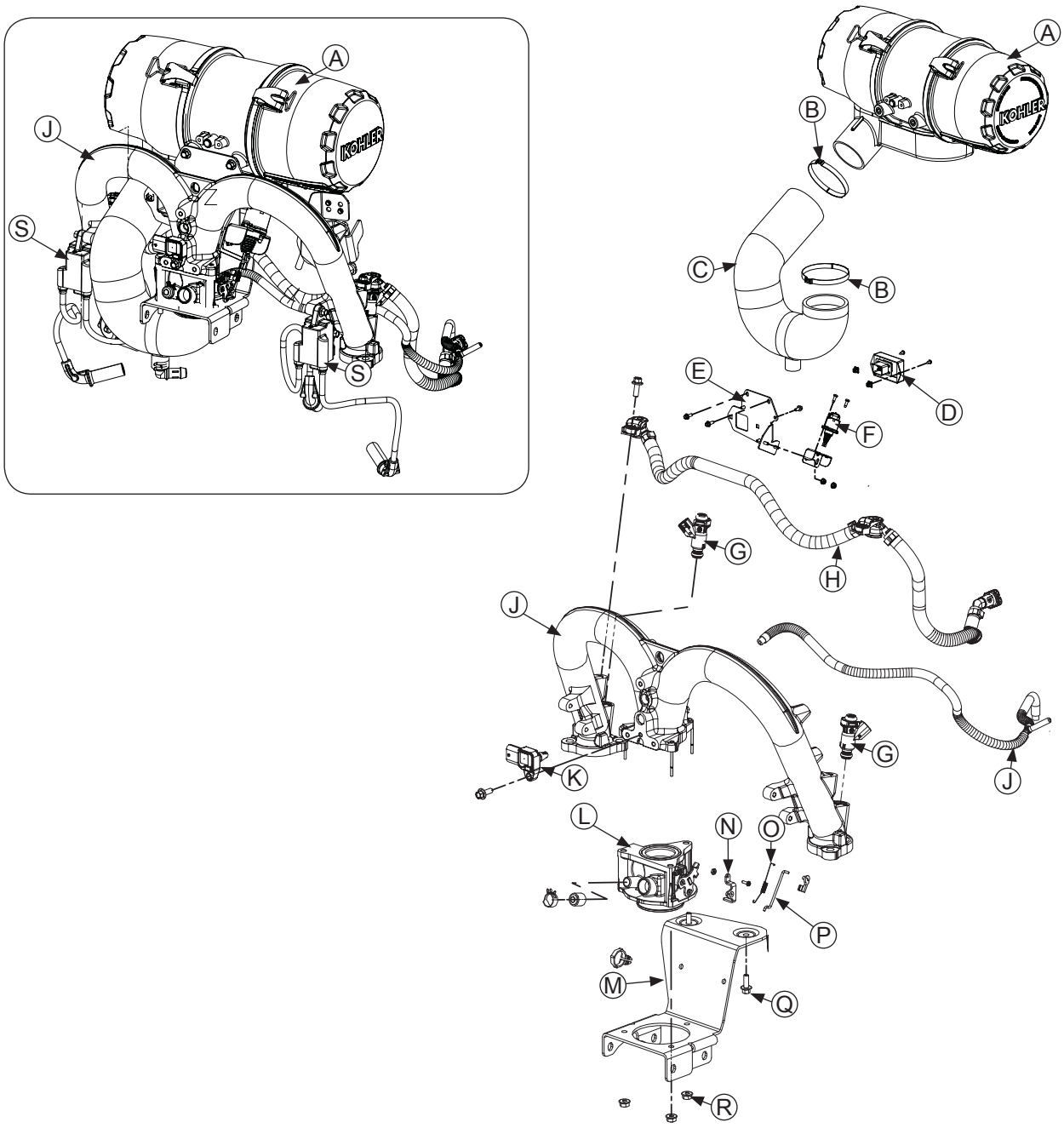
NOTE: Do not use a feeler gauge to measure piston-to-bore clearance; it will yield inaccurate measurements. Always use a micrometer.

Before installing piston into cylinder bore, it is necessary that clearance be accurately checked. This step is often overlooked, and if piston thrust face-to-cylinder bore running clearance is not within 0.026/0.069 mm (0.0010/0.0027 in.), engine failure will usually result.

Use following procedure to accurately measure piston-to-bore clearance:

1. Use a micrometer and measure diameter of piston 11 mm (0.4331 in.) above bottom of piston skirt and perpendicular to piston pin.
2. Use an inside micrometer, telescoping gauge, or bore gauge and measure cylinder bore. Take measurement approximately 63.5 mm (2.5 in.) below top of bore and perpendicular to piston pin.
3. Piston-to-bore clearance is difference between bore diameter and piston diameter (step 2 minus step 1).

Intake Manifold and Throttle Body Assembly Components



A	Air Cleaner	**B**	Clamp	**C**	Air Cleaner Hose	**D**	GCU Module*
E	GCU Module Bracket*	**F**	DLA*	**G**	Injector	**H**	Fuel Rail
I	Vent Hose	**J**	Intake Manifold	**K**	TMAP Sensor	**L**	Throttle Body
M	Throttle Body Bracket	**N**	Throttle Body Lever Adapter	**O**	Linkage Spring	**P**	Throttle Linkage
Q	Screw	**R**	Nut	**S**	Ignition Coil		

*Electronic Governor only.

Remove Throttle Body

1. Cut Oetiker hose clamps securing air cleaner hose to throttle body and air cleaner housing. Remove air cleaner hose from throttle body.
2. Remove screws securing throttle body bracket and air cleaner support bracket. Remove nuts securing throttle body to intake manifold.
3. Disconnect link clip from outboard end of DLA; remove spring and linkage.
4. Remove throttle body with vent hose from studs.
5. Reverse procedure to reassemble, torque fasteners to proper specifications. Secure air cleaner hose to housing and throttle body with new screw-type clamps. Torque air cleaner support bracket to throttle body bracket screws to 10.2 N·m (90 in. lb.); throttle body nuts to 6.8 N·m (60 in. lb.).

Remove GCU (Electronic Governor)

1. Remove screws securing GCU to GCU bracket.
2. Unplug wiring harness connector from GCU.
3. Reverse procedure to install. Torque screws to 3.1 N·m (27 in. lb.).

Remove Ignition Coils

1. Remove screws securing ignition coils to intake manifold. Remove coils.
2. Reverse procedure to install. Torque screws to 10.2 N·m (90 in. lb.).

Remove Fuel Injectors

1. Remove screw for each injector and pull injector out of intake manifold.
2. When removed, pull metal retaining clip connecting fuel injector to fuel injector cap. There may be some fuel left in line. Any spilled fuel must be cleaned up immediately.
3. Reverse procedure to install. Torque fuel injector cap screws to 7.3 N·m (65 in. lb.).

Remove TMAP Sensor

Remove screw and pull TMAP sensor out of intake manifold. Install sensor and secure with screw. Torque screw to 7.3 N·m (65 in. lb.).

Remove Fuel Pump Assembly

⚠ WARNING

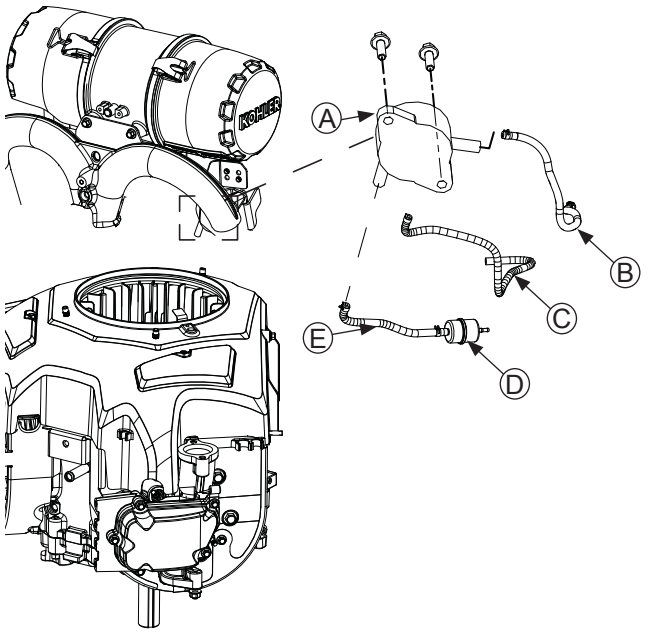
Explosive Fuel can cause fires and severe burns.

Do not fill fuel tank while engine is hot or running.

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Never use gasoline as a cleaning agent.

Fuel pump was removed as part of intake manifold assembly. An exploded view of that assembly with steps to disassemble it follow.

Fuel Pump Assembly Components



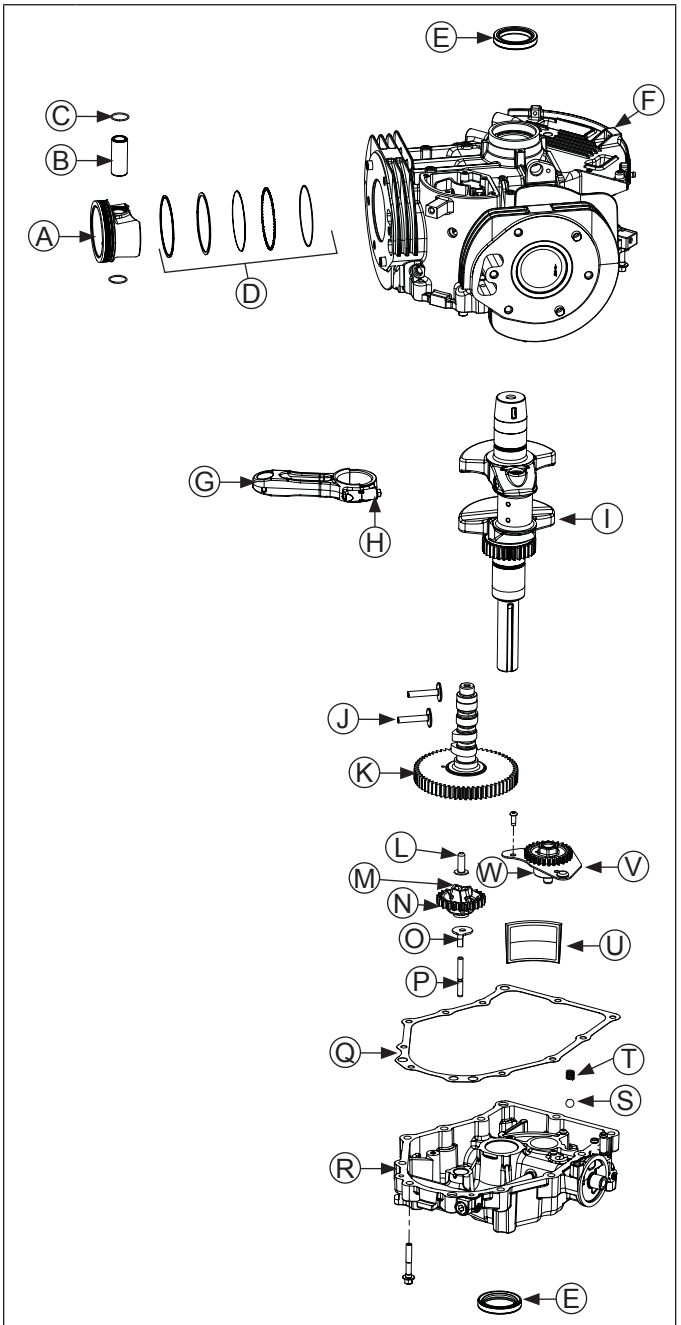
A	Fuel Pump	**B**	Outlet Line
C	Pulse Line	**D**	Fuel Filter
E	Inlet Line		

1. Disconnect outlet line, pulse line, and inlet line from fuel pump.

   Fuel filter may stay attached to inlet line.
2. Remove 2 screws securing fuel pump to bracket on intake manifold and remove fuel pump.
3. Remove screws securing bracket to intake manifold and remove bracket.
4. Reverse procedure to install. Torque screws to 8.2 N·m (73 in. lb.).

Reassembly

Crankcase Components



A	Piston	**B**	Piston Pin
C	Piston Pin Retainer Clip	**D**	Piston Rings
E	Oil Seal	**F**	Crankcase
G	Connecting Rod	**H**	Connecting Rod End Cap
I	Crankshaft	**J**	Tappet
K	Camshaft	**L**	Regulating Pin*
M	Flyweight*	**N**	Governor Gear*
O	Locking Tab Thrust Washer*	**P**	Governor Gear Shaft*
Q	Gasket	**R**	Oil Pan
S	Relief Ball	**T**	Spring
U	Oil Screen	**V**	Oil Pump
W	Geroter Gear		

*Mechanical Governor only.

NOTE: Make sure engine is assembled using all specified torque values, torque sequences, and clearances. Failure to observe specifications could cause severe engine wear or damage. Always use new gaskets. Apply a small amount of oil to threads of critical fasteners before assembly, unless a sealant or Loctite® is specified or preapplied.

Make sure all traces of any cleaner are removed before engine is assembled and placed into operation. Even small amounts of these cleaners can quickly break down lubricating properties of engine oil.

Check oil pan, crankcase, cylinder heads, and valve covers to be certain all old gasket material has been removed. Use gasket remover, lacquer thinner, or paint remover to remove any remaining traces. Clean surfaces with isopropyl alcohol, acetone, lacquer thinner, or electrical contact cleaner.

Install Flywheel End Oil Seal

1. Make sure seal bore of crankcase is clean and free of any nicks or burrs.
2. Apply a light coat of clean engine oil to outside diameter of oil seal.
3. Install oil seal into crankcase using a seal driver. Make sure oil seal is installed straight and true in bore and tool bottoms against crankcase.

Install Governor Cross Shaft (Mechanical Governor)

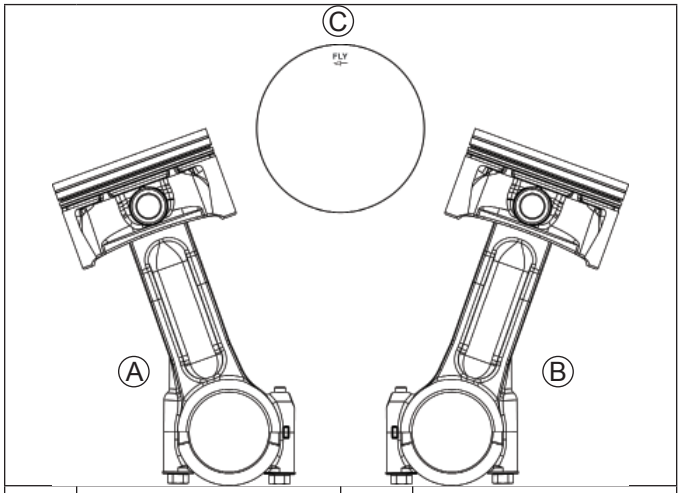
1. Lubricate governor cross shaft bearing surfaces in crankcase with engine oil.
2. Slide lower washer onto governor cross shaft and install cross shaft from inside of crankcase.
3. Install nylon washer onto governor cross shaft, then start push-on retaining ring. Hold cross shaft up in position, place a 0.50 mm (0.0020 in.) feeler gauge on top of nylon washer, and push retaining ring down shaft to secure. Remove feeler gauge, which will have established proper end play.

Install Crankshaft

Carefully slide flywheel end of crankshaft through oil seal in crankcase.

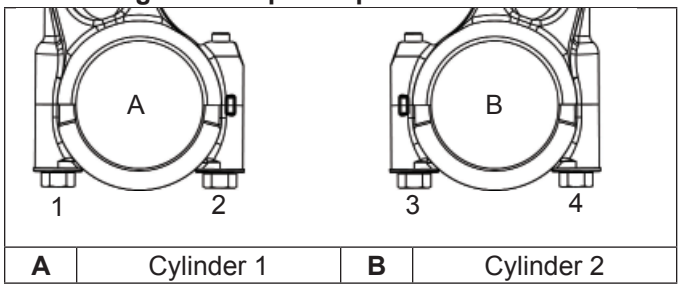
Install Connecting Rods with Pistons and Rings

Piston Details



A	Side 1	**B**	Side 2
C	Top of Piston		

Connecting Rod Torque Sequence



A	Cylinder 1	**B**	Cylinder 2

NOTE: Cylinders are numbered on crankcase. Make sure to install piston, connecting rod and end cap into appropriate cylinder bore as previously marked at disassembly. Do not mix end caps and connecting rods.

NOTE: Proper orientation of piston/connecting rod assemblies inside engine is extremely important. Improper orientation can cause extensive wear or damage. Be certain pistons and connecting rods are assembled exactly as shown.

1. If piston rings were removed, refer to Disassembly/ Inspection and Service procedure to install new rings.
2. Lubricate cylinder bore, piston, and piston rings with engine oil. Compress rings of piston side 1 using a piston ring compressor.
3. Lubricate crankshaft journals and connecting rod bearing surfaces with engine oil.
4. Make sure FLY stamping on piston is facing toward flywheel side of engine. Use a hammer with a rubber grip and gently tap piston into cylinder. Be careful oil ring rails do not spring free between bottom of ring compressor and top of cylinder.
5. Install inner rod cap to connecting rod using screws. Torque screws in increments to 11.6 N·m (103 in. lb.). Illustrated instructions are provided in service rod package.

   Align chamfer of connecting rod with chamfer of its mating end cap. When installed, flat faces of connecting rods should face each other. Faces with raised rib should be toward outside.
6. Repeat this procedure for other connecting rod and piston assembly.

Install Valve Tappets and Camshaft

NOTE: Exhaust valve tappets are located on output shaft side of engine, while intake valve tappets are located on fan side of engine. Cylinder number is embossed on outside of each cylinder on crankcase. Valve tappets should always be installed in same position as before disassembly.

1. Apply camshaft lubricant to contact surface of valve tappets. Note mark or tag identifying tappets and install them in their appropriate crankcase locations. A small amount of grease applied to stems will hold valve tappets up until camshaft is installed.
2. Liberally apply camshaft lubricant to lobes of camshaft. Lubricate camshaft bearing surfaces of crankcase and camshaft with engine oil.
3. Position timing mark of crankshaft gear at 12 o'clock position.
4. Turn governor cross shaft clockwise until lower end (blade) is laying against bottom of cylinder. Make sure cross shaft remains in this position while installing camshaft.
5. Slide camshaft into bearing surface of crankcase, positioning timing mark of camshaft gear at 6 o'clock position. Make sure camshaft gear and crankshaft gear mesh with both timing marks aligned.

Determining Camshaft End Play

1. Place a new oil pan gasket into position on crankcase.
2. Position camshaft end play checking tool over camshaft. Use a feeler gauge to check end play between camshaft and end play checking tool. Camshaft end play should be between 0.147/0.495 mm (0.006/0.019 in.).
3. No shim is typically used from factory. However, if camshaft end play is not within specified range, remove checking tool and shim as necessary.

Several color coded shims are available:

White: 0.69215/0.73025 mm (0.02725/0.02875 in.)

Blue: 0.74295/0.78105 mm (0.02925/0.03075 in.)

Red: 0.79375/0.83185 mm (0.03125/0.03275 in.)

Yellow: 0.84455/0.88265 mm (0.03325/0.03475 in.)

Green: 0.89535/0.99345 mm (0.03525/0.03675 in.)

Gray: 0.94615/0.98425 mm (0.03725/0.03875 in.)

Black: 0.99695/1.03505 mm (0.03925/0.04075 in.)

4. Reinstall end play checking tool and recheck end play.

Reassembly

Oil Pump Assembly

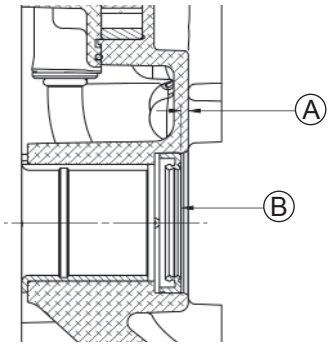
Oil pump is mounted inside oil pan. If service was required and oil pump was removed, refer to Disassembly/Inspection and Service procedure.

Governor Assembly

Governor assembly is located inside oil pan. If service was required and governor was removed, refer to Disassembly/Inspection and Service procedure.

Install Oil Pan Seal

PTO Oil Seal Details

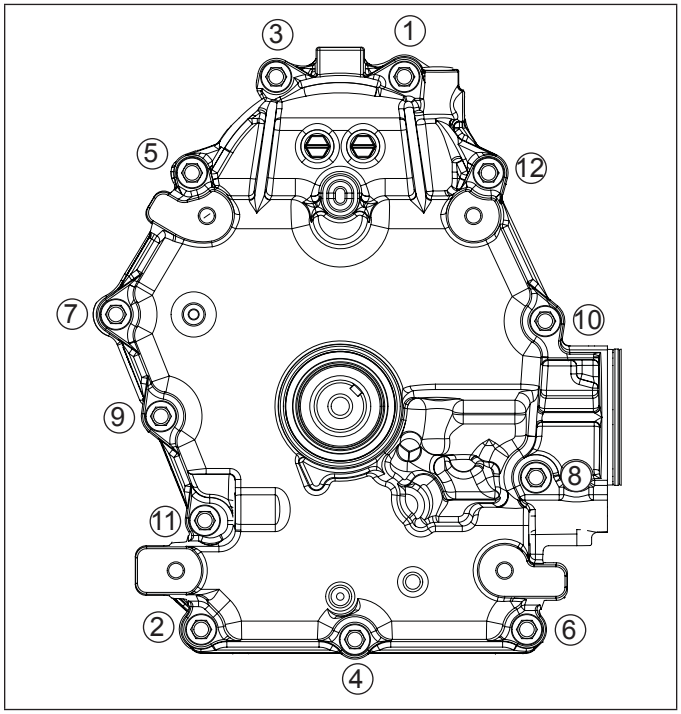


A	3.0 mm (0.118 in.)	**B**	Oil Seal

1. Check to make sure there are no nicks or burrs in crankshaft seal bore of oil pan.
2. Lightly oil outside diameter of oil seal.
3. Install oil seal into oil pan using a seal driver. Make sure oil seal is installed straight and true in bore to depth shown.

Install Oil Pan Assembly

Torque Sequence

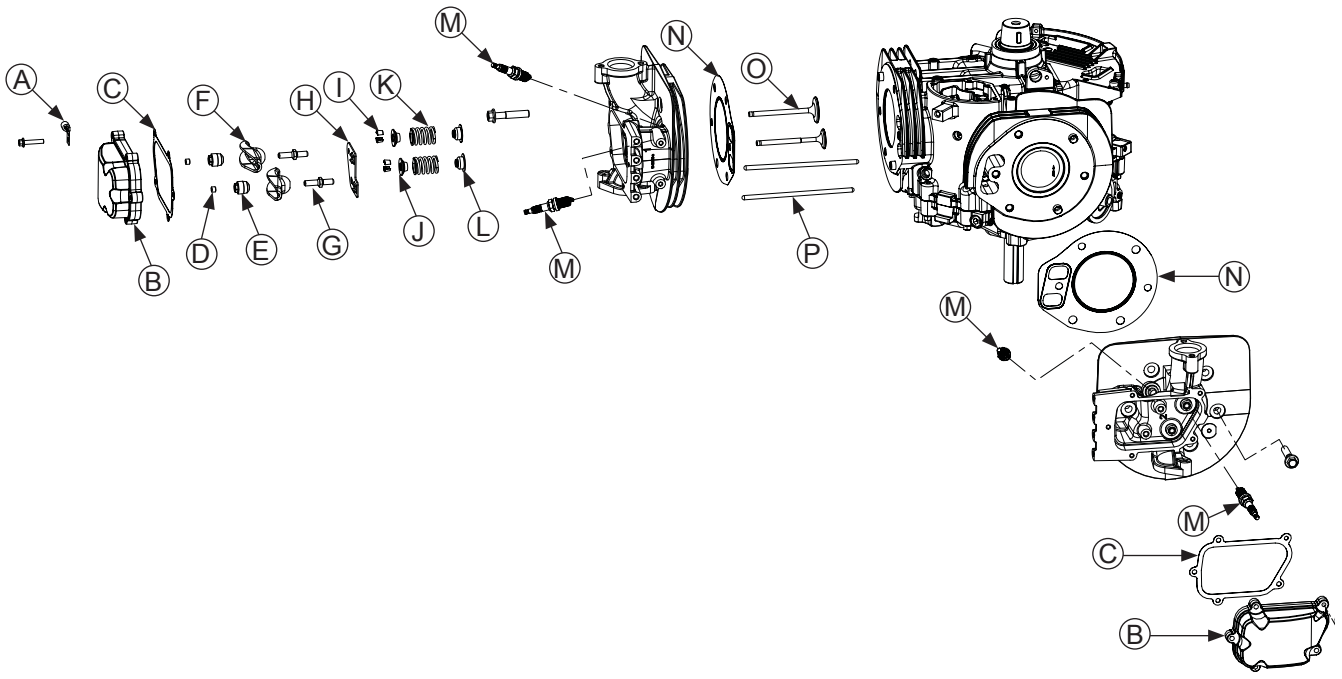


1. Make sure sealing surfaces of oil pan and crankcase are clean, dry, and free of any nicks or burrs.
2. Install a new oil pan gasket onto crankcase and two O-rings on oil transfer passages.
3. Make sure oil pump is installed in oil pan.
4. Ensure end of locking tab washer on governor gear is positioned outward in 6 o'clock position inside crankcase.
5. Orient flat of oil pump gear to match position of flat on camshaft. Install oil pan to crankcase. Carefully seat camshaft and crankshaft into their mating bearings. Rotate crankshaft slightly to help oil pump and governor gears mesh.
6. Lightly oil threads and install screws securing oil pan to crankcase. Torque fasteners in sequence shown to 25.6 N·m (227 in. lb.).

Check Crankshaft End Play

Set engine on base and use a dial indicator to check crankshaft end play. Camshaft end play should be between 0.104/0.532 mm (0.0041/0.0209 in.).

Cylinder Head Components



A	J-Clip	**B**	Valve Cover	**C**	Gasket	**D**	Set Screw
E	Rocker Arm Pivot	**F**	Rocker Arm	**G**	Rocker Arm Stud	**H**	Push Rod Guide Plate
I	Valve Spring Keepers	**J**	Valve Spring Cap	**K**	Valve Spring	**L**	Valve Stem Seal
M	Spark Plug	**N**	Head Gasket	**O**	Valve	**P**	Push Rod

Valve Stem Seals

These engines use valve stem seals on intake and exhaust valves. Always use new seals whenever valves are removed from cylinder head. Seals should also be replaced if worn or damaged. Never reuse an old seal.

Assemble Cylinder Heads

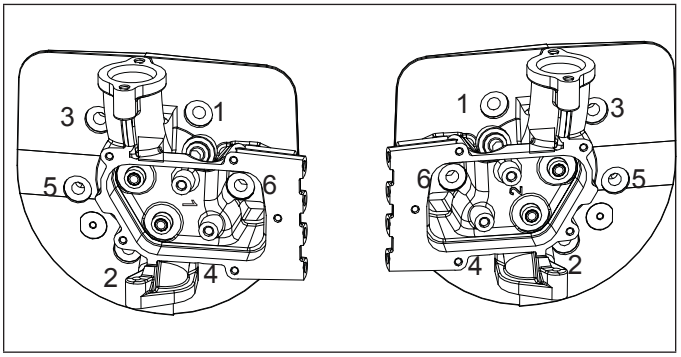
Prior to installation, lubricate all components with engine oil, paying particular attention to lip of valve stem seal, valve stems, and valve guides. Install in order listed below using a valve spring compressor.

- Intake and exhaust valves
- Valve stem seals.
- Valve springs.
- Valve spring caps.
- Valve spring keepers.

Reassembly

Install Cylinder Heads

Torque Sequence



NOTE: Match numbers embossed on cylinder heads and crankcase.

1. Check to make sure there are no nicks or burrs on sealing surfaces of cylinder head or crankcase.
2. Check dowel pins are in place in 2 locations, and install a new cylinder head gasket.
3. Install cylinder head. Make sure head is flat on gasket and dowel pins. Start 6 screws.
4. Torque screws in 2 stages, first to 23.7 N·m (210 in. lb.), finally to 46.9 N·m (415 in. lb.) following sequence shown.
5. Repeat procedure for opposite cylinder.

Install Guide Plate, Rocker Arm Pivot, Push Rods and Rocker Arms

NOTE: Install rocker arm stud with coarse threads into head.

1. Install push rod guide plate and rocker arm studs onto cylinder heads if removed previously. Torque studs to 24.0 N·m (212 in. lb.).
2. Note mark or tag identifying push rod as either intake or exhaust and cylinder 1 or 2. Dip ends of push rods in engine oil and install, making sure each push rod ball seats in its socket.
3. Apply grease to contact surfaces of rocker arms and rocker arm pivots. Install rocker arms, rocker arm pivots, and set screws.

Adjust Valve Clearance

NOTE: It takes two hands to make lash adjustment. A clamping device or an assistant to hold lifter compressed while making adjustment will make process easier.

1. Turn set screw in rocker arm pivots by hand clockwise (down), only enough to capture push rods in recesses.
2. Rotate crankshaft to establish TDC on compression stroke for cylinder 1.

   Check for:

   a. Compression will be felt through spark plug hole.

   b. Keyway of crankshaft will be aligned with cylinder 1.

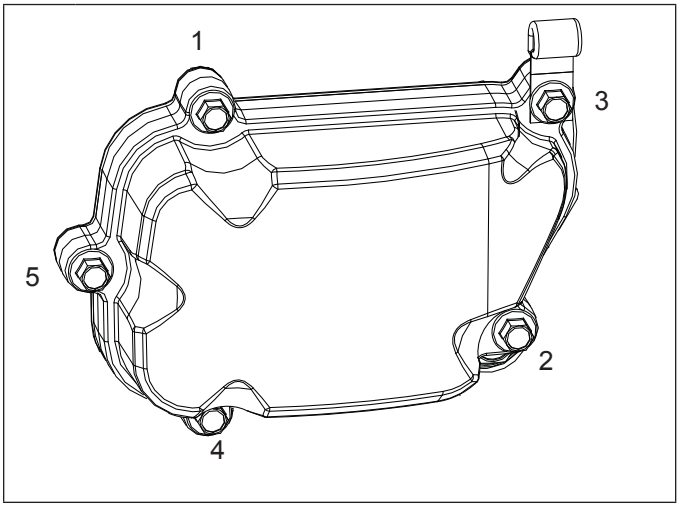
   c. No rocker arm/push rod movement if crankshaft is rotated slightly back and forth. If they are moving, rotate crankshaft one full revolution.
3. Insert a 0.127 mm (0.005 in.) feeler gauge between end of one valve and rocker arm.
4. Turn set screw until a slight drag is felt.
5. Hold in this position and tighten set screw securely. Torque set screw to 7.8 N·m (69 in. lb.), then recheck adjustment.
6. Proper clearance for all valves is 0.050/0.127 mm (0.0020/0.0050 in.).
7. Repeat procedure for other cylinder.

Check Assembly

Rotate crankshaft a minimum of two revolutions to check assembly and overall proper operation.

Install Valve Covers

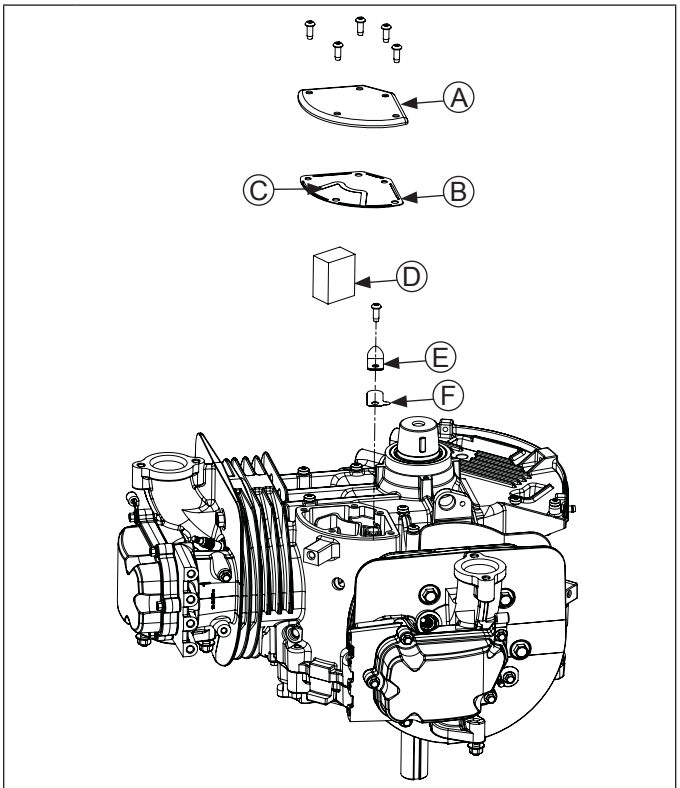
Torque Sequence



1. Make sure sealing surfaces are clean and free of any nicks or burrs.
2. Install valve covers on same side as they were originally installed using new gaskets.

   A J-Clip is mounted on screw closest to intake port.
3. Check position of each cover and gasket, then torque screws to 10.9 N·m (96 in. lb.) using sequence shown.

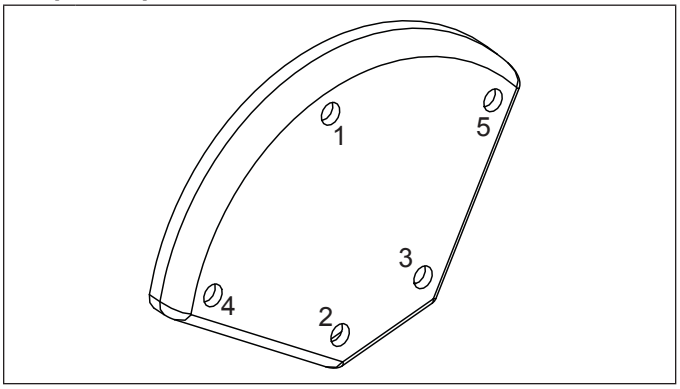
Breather Assembly Components



A	Breather Cover	**B**	Gasket
C	Sealant Bead	**D**	Filter
E	Reed Retainer	**F**	Reed

Install Breather Assembly

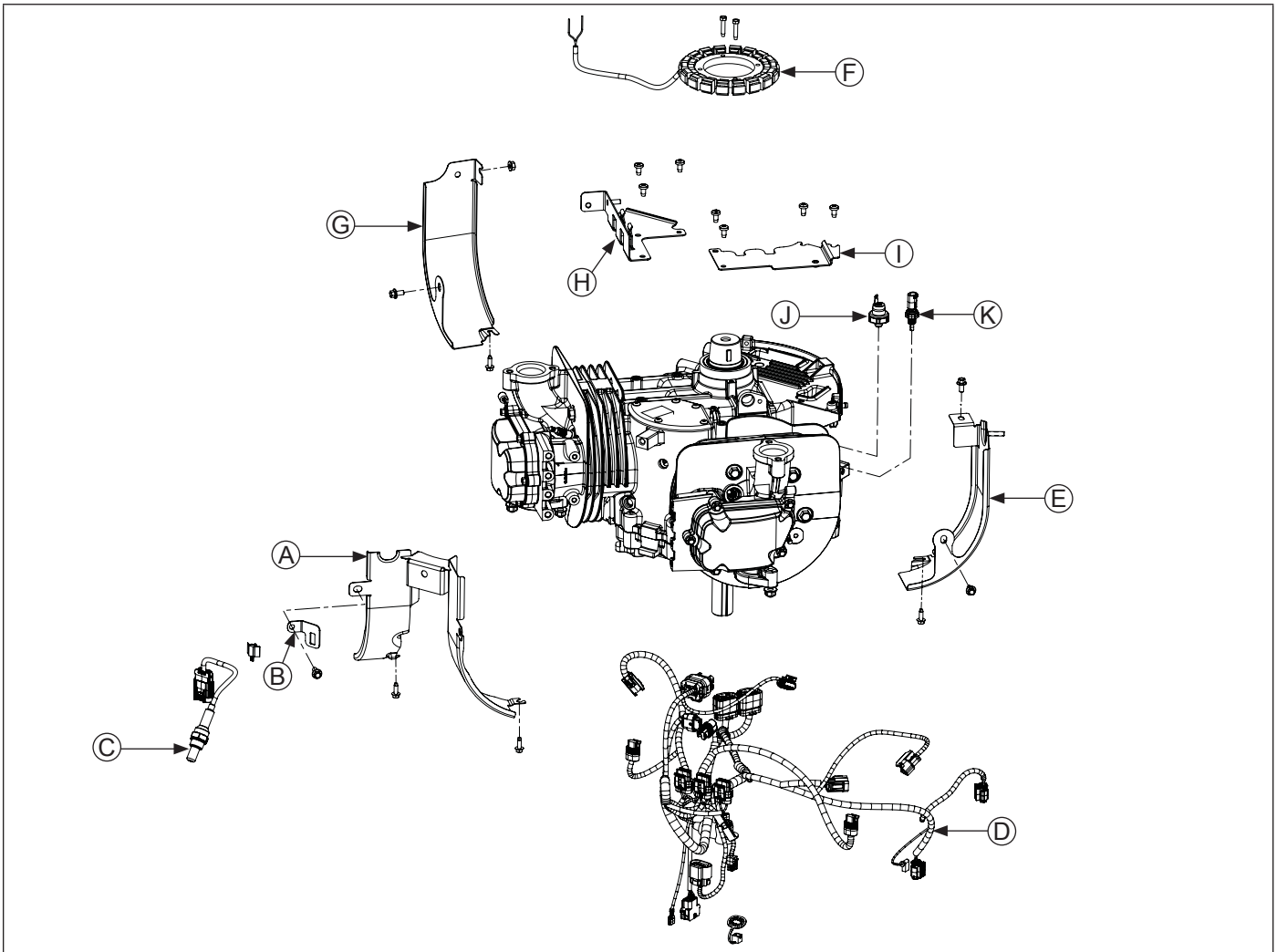
Torque Sequence



1. Make sure sealing surfaces of crankcase and breather cover are clean and free of any nicks or burrs. Do not scrape surfaces, as this could result in leakage.
2. Install reed and reed retainer. Torque screw to 11.3 N·m (100 in. lb.).
3. Install filter. Make sure filter does not extend above top surface.
4. Install breather gasket with sealant bead up (towards cover).
5. Install cover and screws. Torque to 11.3 N·m (100 in. lb.) following sequence.

Reassembly

Baffles/Wire Harness/Stator Components



A	Valley Baffle	**B**	Mounting Bracket	**C**	O2 Sensor	**D**	Wire Harness
E	Cylinder #2 Baffle	**F**	Stator	**G**	Cylinder #1 Baffle	**H**	Crankcase Baffle #1
I	Crankcase Baffle #2	**J**	Oil Pressure Switch	**K**	Oil Temperature Sensor		

Install Valley, Crankcase, and Cylinder Baffles

1. Install crankcase baffles. Secure with screws. Torque M6 screws going into crankcase to 11.3 N·m (100 in. lb.) into new holes, or 7.7 N·m (68 in. lb.) into used holes.
2. Install valley baffle and secure with screws. Torque M6 screws to 8.2 N·m (73 in. lb.). Reinstall wire harness clip to baffle.
3. Install cylinder barrel baffles. Make sure spark plug lead is routed through corresponding opening in each baffle. Start each screw. Torque M6 screws to 8.2 N·m (73 in. lb.); torque M5 screws to 6.3 N·m (56 in. lb.) into new holes, or 4.0 N·m (35 in. lb.) into used holes.

Install Stator and Wire Harness

1. Position stator and wire harness on crankcase, aligning mounting holes, with stator lead toward cylinder #1 side. Route stator lead between electric starter boss, #1 crankcase baffle, and crankcase rib.
2. Apply pipe sealant with Teflon® (Loctite® PST® 592™ Thread Sealant or equivalent) to stator mounting holes and secure with two screws. Torque screws to 9.3 N·m (82 in. lb.) into new holes, or 4.0 N·m (35 in. lb.) into used holes.

   Install harness into baffle clips in a way that will not interfere with flywheel.
3. Attach harness ground to crankcase.

Install Oil Sentry™ Pressure Switch (if equipped)

1. Apply pipe sealant with Teflon® (Loctite® PST® 592™ Thread Sealant or equivalent) to Oil Sentry™ threads switch and install it into 1/8 in. port in oil pan. Torque switch to 9.0 N·m (80 in. lb.).
2. Connect green wire lead to Oil Sentry™ terminal.

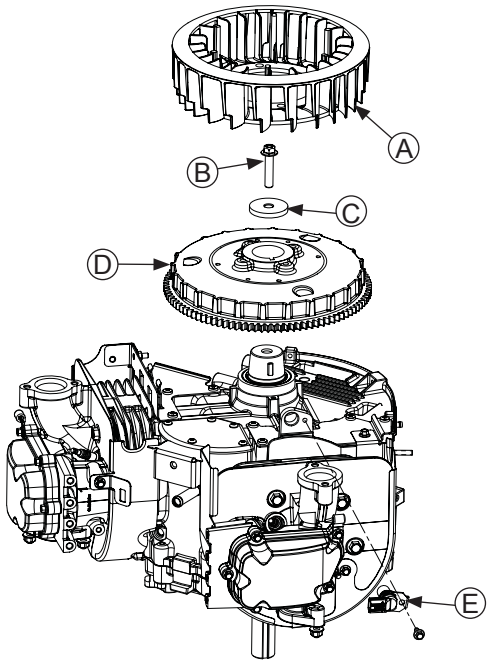
Install Oil Temperature Sensor

NOTE: Ensure part is clean, undamaged and free of debris and make sure electrical connector has seal in place.

1. Lightly lubricate oil temperature sensor O-ring and install oil temperature sensor into oil pan.
2. Torque sensor to 7.3 N·m (65 in. lb.).
3. Push electrical connector on oil temperature sensor making sure a good connection is made.

Install Flywheel/Fan

Flywheel/Fan Components



A	Flywheel Fan	**B**	Flywheel Screw
C	Washer	**D**	Flywheel
E	Crankshaft Position Sensor		

⚠ CAUTION

Damaging Crankshaft and Flywheel can cause personal injury.

Using improper procedures can lead to broken fragments. Broken fragments could be thrown from engine. Always observe and use precautions and procedures when installing flywheel.

NOTE: Before installing flywheel make sure crankshaft taper and flywheel hub are clean, dry, and completely free of any lubricants. Presence of lubricants can cause flywheel to be over stressed and damaged when screw is torqued to specifications.

NOTE: Make sure flywheel key is installed properly in keyway. Flywheel can become cracked or damaged if key is not properly installed.

1. Install woodruff key into crankshaft keyway. Make sure key is properly seated and parallel with shaft taper.
2. Set flywheel onto crankshaft, being careful not to shift woodruff key.
3. Install screw and washer.
4. Use a flywheel strap wrench or holding tool to hold flywheel. Torque screw to 71.6 N·m (53 ft. lb.).

Install Fan

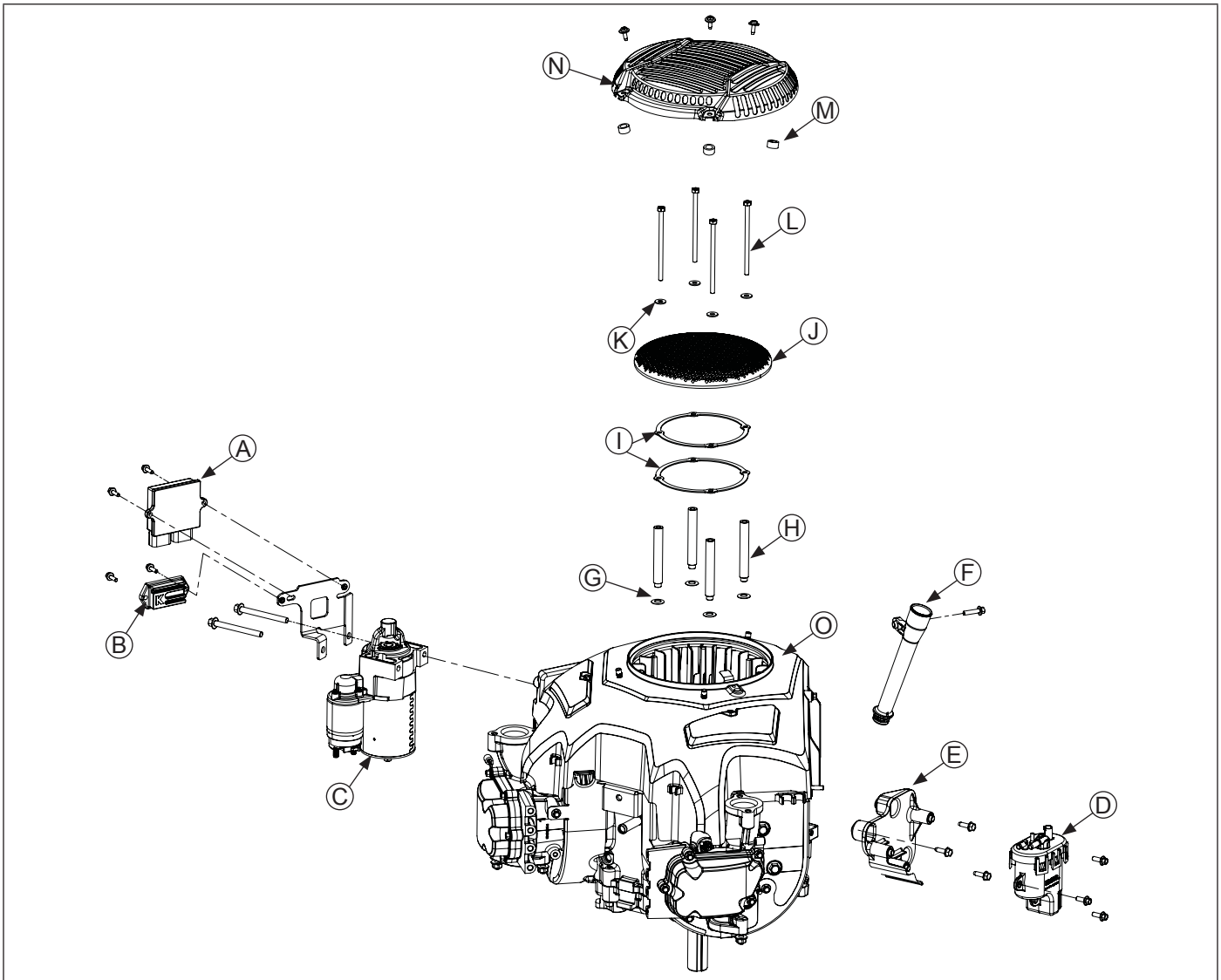
Set fan on flywheel with locating tabs on back of fan in locating holes of flywheel.

Install Crankshaft Position Sensor

Install crankshaft position sensor with harness and secure with screw. Torque screw to 8.2 N·m (73 in. lb.) into a new hole, or 7.7 N·m (68 in. lb.) into a used hole.

Reassembly

Blower Housing/Starter Motor/Fuel Pump Components



A	ECU	**B**	Rectifier-Regulator	**C**	Starter Motor Assembly	**D**	Fuel Pump Module
E	Fuel Pump Module Baffle	**F**	Oil Fill Tube	**G**	Washer	**H**	Spacer
I	Support Rings	**J**	Debris Screen	**K**	Washer	**L**	Screw
M	Spacer	**N**	Fixed Guard	**O**	Blower Housing		

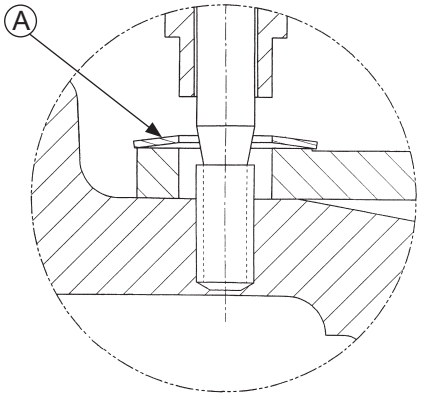
Install Blower Housing

NOTE: ECU pins should be coated with a thin layer of electrical grease to prevent fretting and corrosion and may need to be reapplied if ECU is being reused.

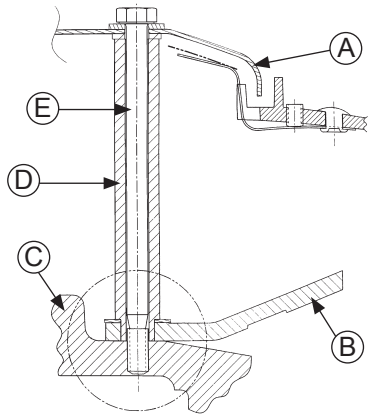
1. Install blower housing and secure with screws and nuts. Torque fasteners to 4.8 N·m (42 in. lb.).
2. If ECU or rectifier-regulator were removed from bracket/blower housing, install them now. Torque screws to 5.6 N·m (50 in. lb.).
3. Plug wire harness into ECU and rectifier-regulator.
4. Install oil fill tube into crankcase. Secure with mounting screw. Torque screw to 7.7 N·m (68 in. lb.).

Install Metal Debris Screen

Spring Washer Details



A	Spring Washer



A	Metal Debris Screen	**B**	Fan
C	Flywheel	**D**	Spacer
E	Hex Screen		

1. To assist assembly, find intake manifold studs with M6 thread at least 100 mm in length to be used as guide pins. Insert intake manifold studs through cooling fan mounting holes and thread them 4 or 5 turns into flywheel.
2. Install a spring washer on each stud with concave side down toward cooling fan.
3. Install a spacer on each stud with stepped end down. Smaller diameter should extend through spring washer and fan, so tip is resting on flywheel, and shoulder is resting on spring washer.
4. Install support rings on studs, so they are resting on spacers. Then install metal screen on top of support rings.
5. Install a plain washer on each screws. Apply Loctite® 242® to screw threads.
6. Carefully remove studs and replace with screws. Torque screws to 9.9 N·m (88 in. lb.). Repeat procedure for other studs and screws.

Install Fixed Guard

Install spacers and fixed guard. Secure with three screws. Torque screws to 1.4 N·m (12 in. lb.).

Install Starter Motor

1. Install electric starter motor using screws.
2. Torque screws to 16.0 N·m (142 in. lb.).
3. Connect main power lead and solenoid lead. Attach harness wires.

Install Fuel Pump Module (FPM)

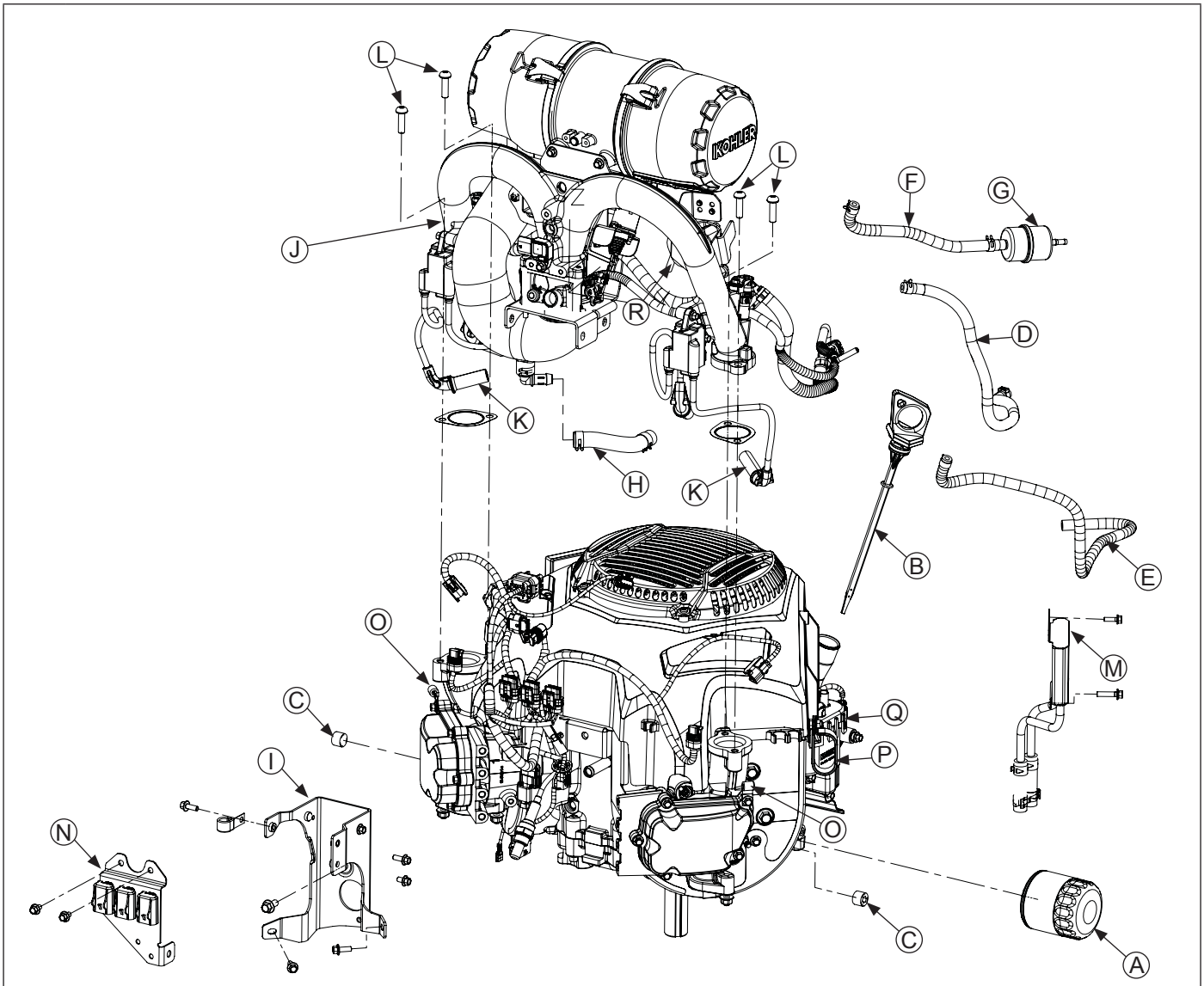
NOTE: Ensure all parts are clean, undamaged, and free of debris; make sure electrical connector has seal in place.

NOTE: FPM pins should be coated with a thin layer of electrical grease to prevent fretting and corrosion and may be reapplied if fuel pump module is being reused.

1. Orient fuel pump module baffle so pulse fitting in crankcase extends through cutout in baffle.
2. Install screws to secure fuel pump module baffle to crankcase. Torque screws to 11.9 N·m (105 in. lb.) into new holes, or 7.8 N·m (69 in. lb.) into used holes.
3. Install fuel pump module to baffle and torque screws to 9.2 N·m (81 in. lb.).
4. Connect electrical connector to top of fuel pump module. Ensure grey locking tab is pulled out before connecting. Push connector onto terminal until a click us heard, then push in grey locking tab to lock connector.
5. Push high pressure fuel line connector onto FPM fitting.

Reassembly

External Engine Components



A	Oil Filter	**B**	Dipstick	**C**	Oil Drain Plug	**D**	High Pressure Fuel Line
E	Pulse Line	**F**	Low Pressure Fuel Line	**G**	Fuel Filter	**H**	Breather Hose
I	Throttle Body Bracket	**J**	Manifold Assembly	**K**	Spark Plug Lead	**L**	Manifold Screw
M	Oil Cooler	**N**	Fuse Holder Bracket	**O**	J-Clip	**P**	Clamp
Q	Fuel Pump Module (FPM)	**R**	Fuel Pump				

Install Oil Cooler (if equipped)

NOTE: New hose clamps are recommended for reassembly, or if clamps have been loosened (expanded) several times to avoid leakage.

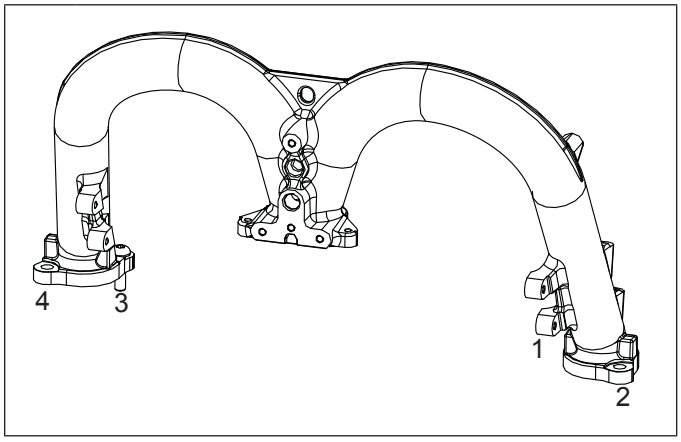
1. Connect hoses between oil cooler and oil pan. Secure with new clamps.
2. Orient new clamps as noted in disassembly.
3. Install screws to secure oil cooler to blower housing. Torque top screw (M5) to 5.6 N·m (50 in. lb.) and bottom screw (M6) to 4.8 N·m (46 in. lb.).

Install Throttle Body Bracket

Loosely install throttle body bracket with screws. Do not tighten at this time.

Install Intake Manifold/Throttle Body Assembly

Torque Sequence

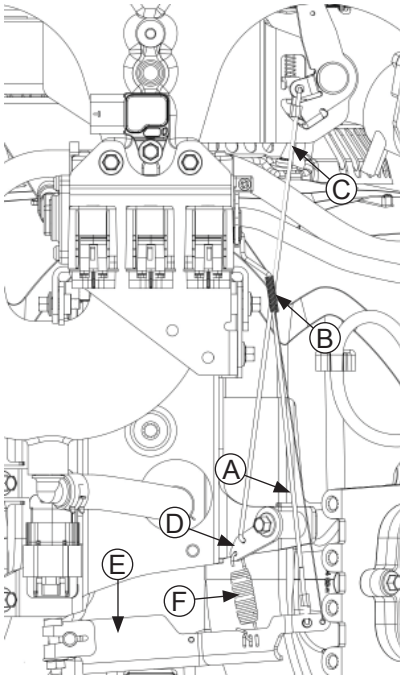


1. Carefully place intake manifold assembly onto engine.

   Throttle body bracket must be behind all wires in harness.
2. Slide intake gaskets between intake ports and manifold. Torque intake manifold screws, using sequence shown, to 16.0 N·m (142 in. lb.).

   Manifold screws must be torqued while throttle body bracket is loose.
3. Torque M6 throttle body bracket screws to 10.2 N·m (90 in. lb.); M8 screw to 16.0 N·m (142 in. lb.).

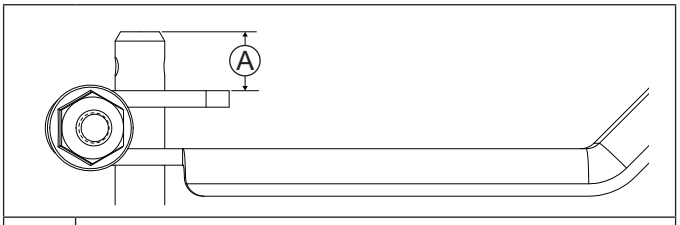
Install Governor Lever, Governor Springs, and Linkage (Mechanical Governor)



A	Governor Linkage	**B**	Linkage Spring
C	Speed Control Linkage	**D**	Governor Linkage Lever
E	Governor Lever	**F**	Governor Spring

1. Connect speed control linkage to governor linkage lever.
2. Connect governor linkage and linkage spring to throttle body and to governor lever.
3. Connect governor spring to governor lever and governor linkage lever.
4. Install governor lever onto governor shaft but do not tighten nut.

Initial Adjustment Procedure



A	9.5 mm ± 0.5 (0.37 in. ± 0.02)

1. Move governor lever toward throttle body as far as it will go (wide open throttle) and hold in this position.
2. Insert a long thin rod or tool into hole on cross shaft and rotate shaft counterclockwise (viewed from end) as far as it will turn.
3. Adjust governor lever to maintain correct location from end of governor cross shaft. Torque nut to 7.1 N·m (63 in. lb.).

Install Breather Hose

Connect and clamp breather hose to elbow on large air intake hose.

Route and Connect Wire Harness

1. Insert diagnostic plug into bracket.
2. Connect fuses to holders in bracket.
3. If equipped with an electronic governor, connect harness to Governor Control Unit (GCU) and route DLA wire behind throttle body and connect.
4. Connect TMAP sensor and remaining sensors, coils, and injectors.
5. Route large harness wires over intake air hose and secure with J-Clip.

Install Fuel Lines

1. If it was removed, install fuel pump to bracket on intake manifold and secure with screws. Torque screws to 8.2 N·m (73 in. lb.).
2. Connect vent and high pressure lines from fuel pump module. Connect and clamp pulse line to fuel pump and to low pressure hose.
3. Place four hoses into retaining bracket and mount to blower housing. Torque nut to 4.8 N·m (42 in. lb.).

Install Oil Filter and Add Oil to Crankcase

1. Install oil drain plugs. Torque plug to 21.4 N·m (15.7 ft. lb.).
2. Place new filter in shallow pan with open end up. Fill with new oil until oil reaches bottom of threads. Allow 2 minutes for oil to be absorbed by filter material.
3. Apply a thin film of clean oil to rubber gasket on new filter.
4. Refer to instructions on oil filter for proper installation.
5. Fill crankcase with new oil. Level should be at top of indicator on dipstick.
6. Reinstall and secure dipstick.

Install Spark Plugs

1. Check gap using wire feeler gauge. Adjust gap to 0.76 mm (0.030 in.).
2. Install plug into cylinder head.
3. Torque plug to 27 N·m (20 ft. lb.).

Connect Spark Plug Leads

Connect leads to spark plugs. Outer wires are secured with J-Clips and inner wires are looped and clipped to blower housing.

Install Fuse Cover (Optional)

Position fuse cover over fuses. Secure with screws and nuts. Torque fasteners to 9.9 N·m (88 in. lb.).

Prepare Engine for Operation

NOTE: If ECU, throttle body, TPS, or fuel pump module were replaced, an ECU Reset and TPS Learn is required. Refer to Electronic Fuel Injection (EFI) System section.

NOTE: If electronic governor and throttle body were removed or replaced, refer to Governor section for proper adjustment/assembly.

Engine is now completely reassembled. Before starting or operating engine, follow proceeding steps.

1. Make sure all hardware is tightened securely.
2. Make sure oil drain plugs, Oil Sentry™ pressure switch, and a new oil filter are installed.
3. Verify crankcase has been filled with correct amount, weight, and type of oil. Refer to oil recommendations and procedures in Maintenance, Specifications, and Lubrication System sections.
4. Turn on fuel supply.

Testing Engine

It is recommended engine be operated on a test stand or bench prior to installation in equipment.

1. Set engine up on a test stand. Install an oil pressure gauge. Start engine and check to be certain oil pressure (20 psi or more) is present. Run engine at idle for 2-3 minutes, then 5-6 minutes more between idle and midrange.
2. Adjust idle speed screw located on throttle body as necessary. Standard idle speed setting for EFI engines is 1500 RPM, but certain applications might require a different setting.
3. **Mechanical Governor**: Adjust governed idle and high speed (RPM) to required settings. Make sure maximum engine speed does not exceed 3900 RPM (no load).
4. **Electronic Governor**: Attach 12 volt jumper wire to speed control input red wire with yellow tracer. Engine speed should increase to high. Make sure maximum engine speed does not exceed 3900 RPM (no load). If engine speed does not increase, refer to Governor section for proper troubleshooting and diagnostics.

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